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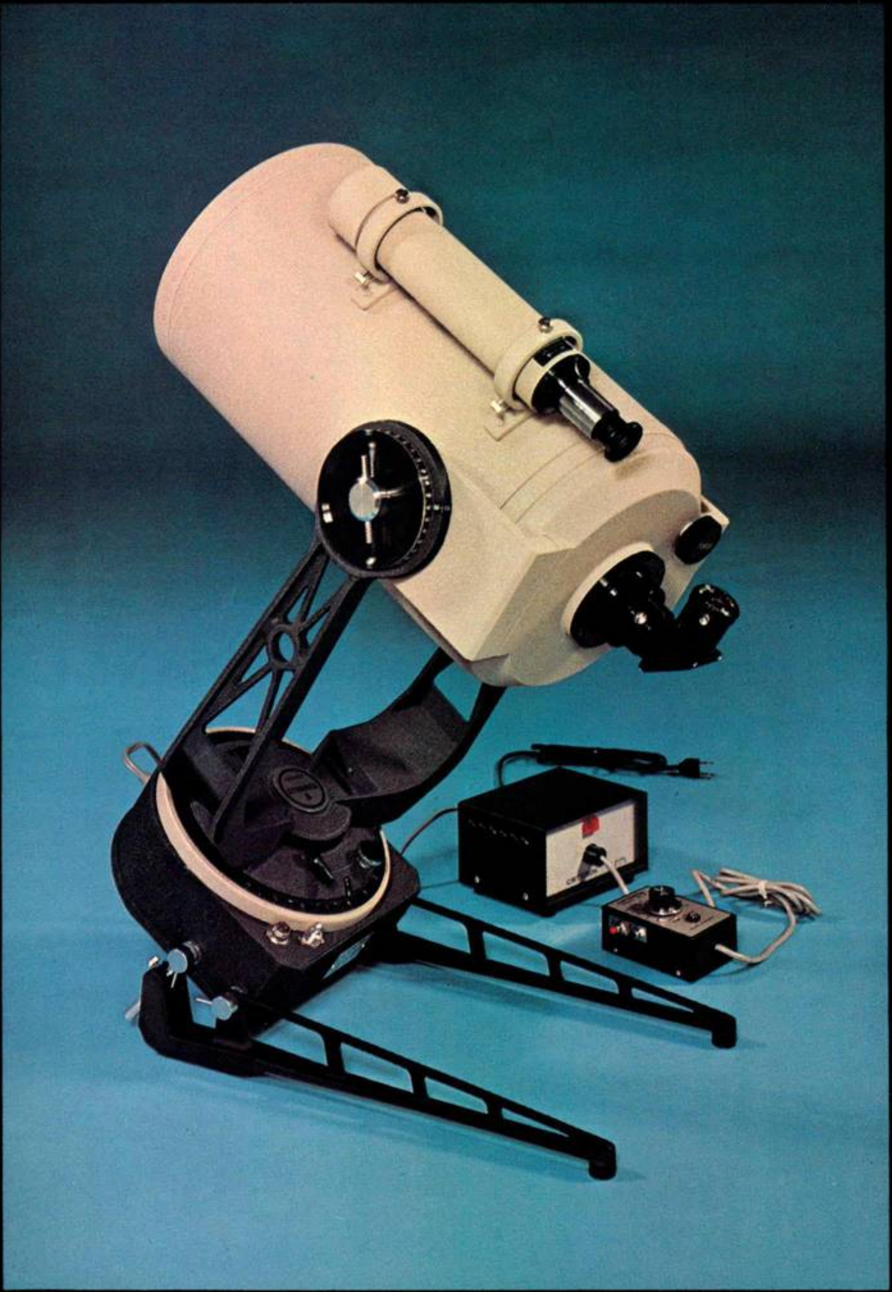

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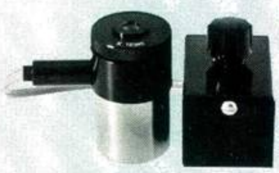

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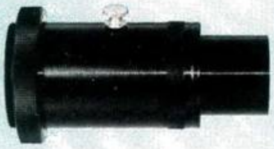

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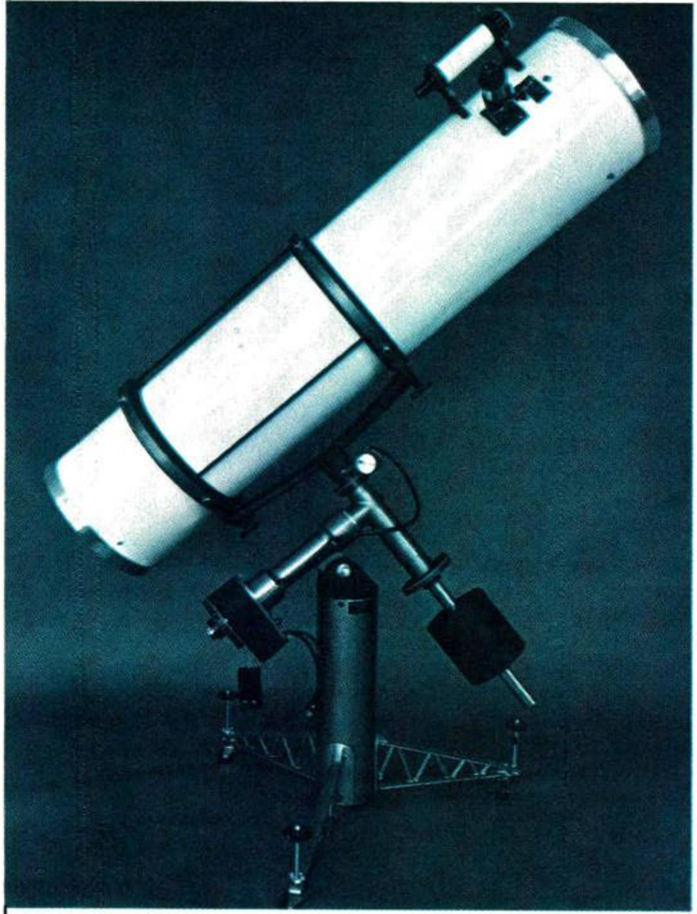

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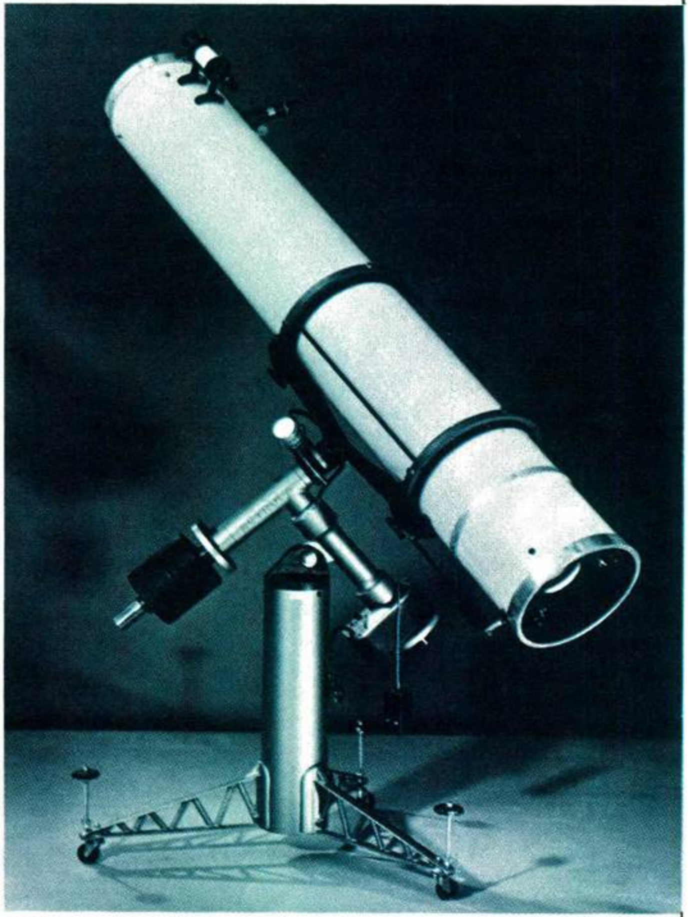

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6 BIG BANG TO GALAXY
by Michael Zeilik
16 ASTRONOMY REVIEWS
18 MARS' NEW FRONTIERS
by William Hartmann
26 GAZER'S GAZETTE
Find a Comet
by Frank Apsi
32 ASTRO-MART
34 SKY ALMANAC
Cygnus Had a Busy Summer
49 GUIDE TO BACK ISSUES
51 IN FOCUS
54 PUBLISHER'S MEMO
55 ASTRO-NEWS
62 STELLAR FRONTIERS
Two X-Ray Stars
by Gerrit L. Verschuur
67 NOVEMBER STAR DOME
72 Close-Up on the Andromeda/Triangulum Region
72 Eyepiece Impressions
76 PLANET FINDER — NOVEMBER 1975

Cover

The cold glow from an elliptical galaxy illuminates the surface of a hypothetical planet at the edge of one of over 400 galaxies in the Coma Berenices galaxy cluster. This tremendous grouping of star systems contains a variety of galactic types in an area no larger than the full moon when seen from Earth. The galaxies recede in the distance — the light of their suns dimmed by the light-years between them despite their apparent proximity in space. Galaxy groups such as the Coma cluster are common in galactic distribution. Artwork by John Clark.

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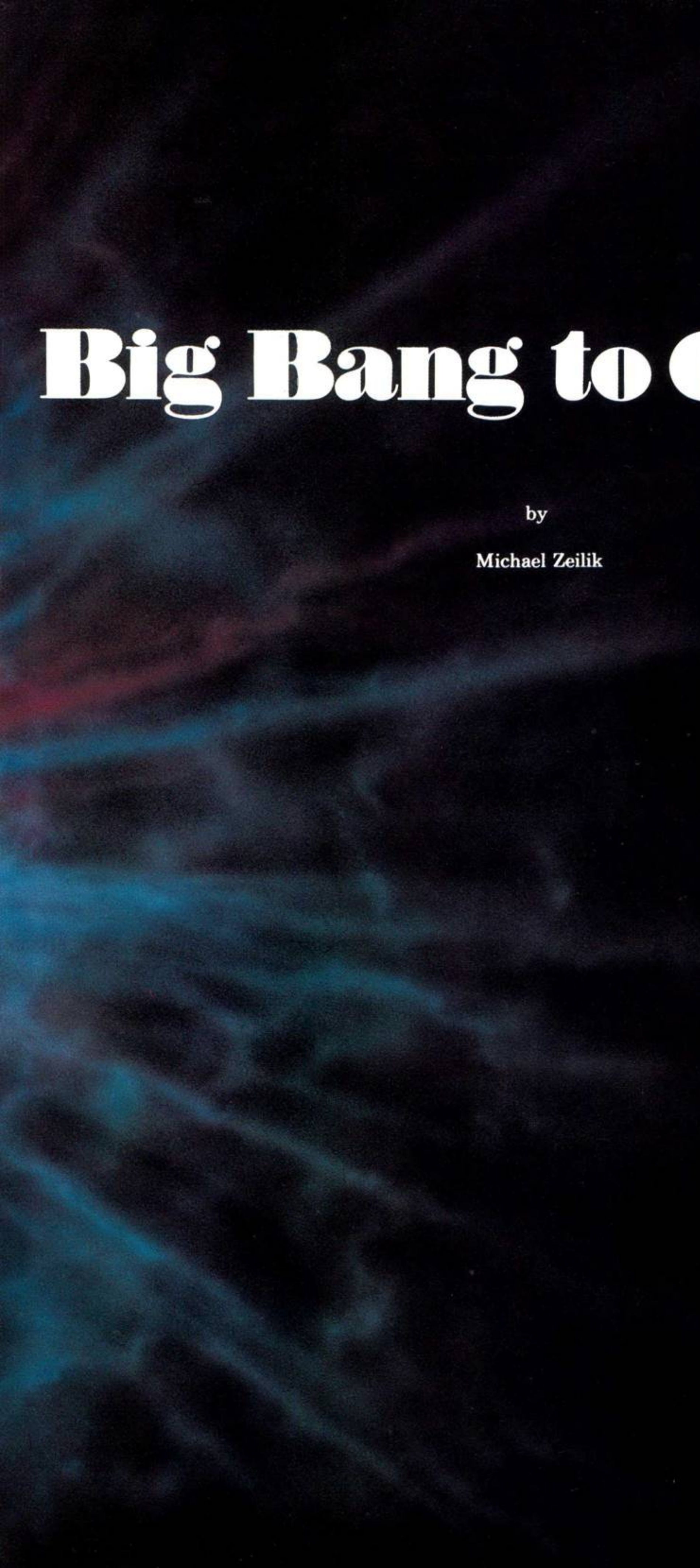


Big Bang to Galaxy

by

Michael Zeilik

Our universe was born out of a primeval fireball — a fireball whose violence created the matter we now see. This event, occurring 15 to 20 billion years ago, was the big bang.

The universe today doesn't appear to offer much evidence of the big bang. But it is there in hidden and obvious forms.

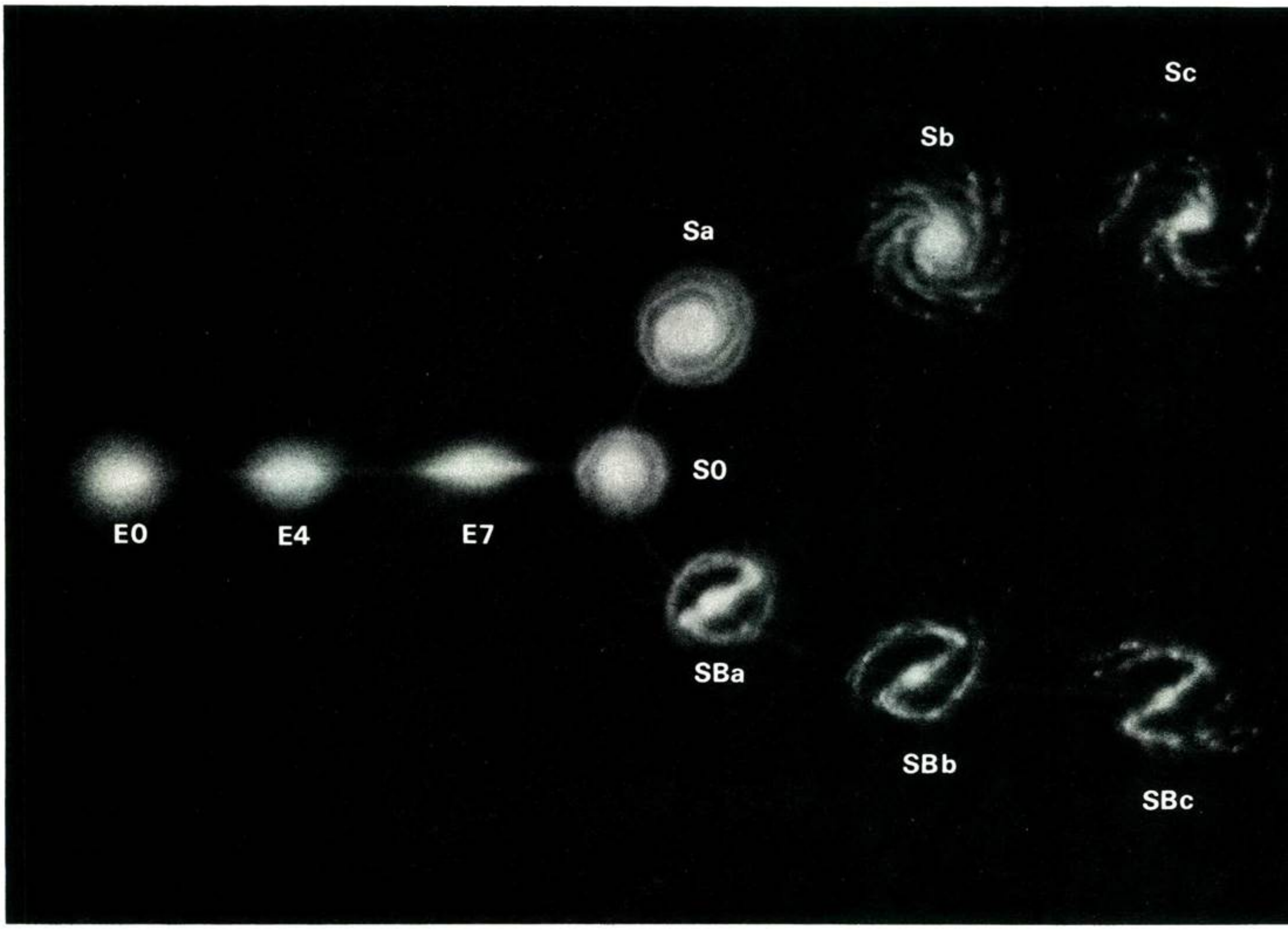
The profusion of galaxies — all expanding from each other — marks the fate of some (if not most) matter in the big bang. As far out in space as they can see with optical telescopes (and so back in time, because light travels at a finite speed), astronomers see galaxies. Recently, galaxy 3C123 was discovered some six billion light-years away from us — roughly 0.3 of the time since the big bang.

Electromagnetic radiation (photons) generated by and left over from the primeval fireball is also evidence of the big bang. This radiation whispers weakly between the stars and galaxies, intercepted only by the ears of sensitive radio receivers tuned to microwave frequencies. Because of the expansion of the universe, the photons that glared in the cosmic burst have lost energy and affect matter in the universe very little now. Matter is the dominant force. (Comparison of the present density of matter with the density of cosmic radiation shows about 1,000 times more matter than cosmic radiation.)

This was not the case in the past. The universe is presently expanding, but imagine it running backwards and collapsing. The matter and radiation both heat up, and their densities increase. Eventually the radiation mass-density becomes greater than that of matter. Then radiation dominates the physical conditions in the universe. Because the present temperature of cosmic radiation (about -454 degrees Fahrenheit) and the age of the universe are known, it is possible to estimate when the radiation ceased to dominate over matter. This happened about 1,000 years after the big bang. At that time, the universe was hot — over 179,000 degrees Fahrenheit! Large matter structures such as planets, stars and galaxies could not exist. All the material was hot, ionized gas. The distribution of matter and photons in space must have been quite uniform.

Caption for Page 6

A cosmic explosion — the big bang — created all the matter visible in the universe. Each galaxy and each star condensed from tenuous gases which burst forth, spread and cooled in this mammoth cataclysm. Visible evidence of this event is the profusion of galaxies in space, but additional proof is electromagnetic radiation detected by sensitive radio telescopes on Earth and in space. Artwork by Victor Costanzo.



Now imagine the universe expanding from this time. The temperatures of matter and radiation drop. When the temperature falls to about 5-7,000 degrees Fahrenheit, protons in the gas capture free electrons and form atoms of hydrogen. A remarkable event happens. As the gas quickly becomes neutral, the universe becomes transparent to its own radiation. Up to this time — some 100,000 light-years after the big bang — the universe was opaque to its own radiation. If an observer could have been there, a bright fog would have been visible all around. It would have been impossible to see very far into this smooth glare. (Imagine sitting inside the visible sphere of the sun. That's roughly how the universe would have looked before the protons and electrons combined to make hydrogen.) Once the matter becomes neutral and transparent to the radiation, the two no longer interact; they decouple.

After decoupling, the radiation flies freely through space and its spectrum appears redshifted. But it preserves information about the universe at the time just before decoupling. Cosmic radiation comes to Earth very uniformly from all directions in space. This implies matter and radiation must have been distributed quite uniformly just before decoupling.

But the matter in the universe is no longer distributed uniformly. It is clumped in stars, galaxies and clusters of galaxies. Clusters of galaxies — which spread over the largest spacial area — have an average density 10 to 100 times greater than the universe.

How did a uniform universe become "clumpy"? Or, how did clusters of galaxies, galaxies and stars form out of the primeval fireball? This question is difficult to answer because direct observation of galaxies, galaxy clusters and stars reveals that random masses do not form. The range of masses is similar to the range found in galaxies — one million to 10 trillion suns. However matter gathers, the process must also account for galaxy clusters with up to a quadrillion suns. In addition, the process bringing matter together has only several billion years to work.

It is gravity that unites matter in the astronomical scheme in a process called *gravitational*

Galaxies are classified by their appearance. Four basic shapes — elliptical, spiral, barred spiral and irregular — comprise the types, with ellipticals (such as M-87 in the photo at left) containing the oldest stars. Mount Wilson photograph; Artwork by Victor Costanzo.

instability. Imagine a uniform, static gas. A disturbance occurs, and a small spherical region becomes slightly more dense than its surroundings. Its gravity increases. The increased gravity attracts more matter, increasing the density of the gas. This process continues; the particles in the disturbed region condense, forming a gravitationally bound object.

Internal pressure also plays a critical role in gravitational instability. Consider a disturbed patch of gas. Its density is higher and gravity greater than undisturbed gas, but its internal pressure has also increased. This pressure tends to push matter apart. Which wins — the inward pull of gravity or the outward push of pressure?

The outcome depends on the size of the disturbed region. If too small, the pressure overcomes gravity and the region compresses like a sound wave. Such waves eventually dissipate. If large enough, gravity is the controlling factor and the region collapses.

When this theory was applied to disturbances in an expanding universe model (described by Einstein's theory of general relativity), a disturbing problem was discovered. The growth rate of gravitational instabilities into bound masses was slow — so slow that galaxies would have just recently formed from small disturbances in the universe.

But the growth analysis of density disturbances was done first before cosmic radiation was discovered. Observations of this relic radiation forced astronomers to reinvestigate what happens to disturbances in a hot, dense universe filled with matter and radiation. Before decoupling, the radiation played a powerful role in inhibiting disturbance growth. A dense patch of gas has a high internal pressure because radiation contributes to the outward pressure force. Only large disturbances have any chance of growth. All smaller disturbances just create sound waves that don't grow in size or density. Even more important, until decoupling occurs, the radiation pressure destroys density disturbances containing less than or up to a trillion suns. Thus, before the decoupling of matter and radiation, disturbances containing roughly the same mass as a galaxy could not grow.

Just after decoupling, the radiation and gas no longer interact — so radiation pressure no longer helps fight gravity. Small disturbances involving only one million suns can condense out of the gas. Common gravitationally bound masses now seen range from about one million suns (globular clusters and small galaxies) to a quadrillion suns (clusters of galaxies). The time of decoupling flags the era when galaxy formation could begin, roughly 100,000 years after the big bang.

Galaxies formed early in the universe but grew very slowly. If gravitational instability alone did not cause their formation, what helped the process along? One contemporary answer is *turbulence* resulting from the big bang. This turbulence increased the growth speed of small disturbances into young galaxies.

Turbulence occurs in whirling cells of material called *eddies.* An example of turbulent eddies is the small whirlpools produced in water when an object moves quickly through it. These eddies eventually die out because of friction between water molecules.

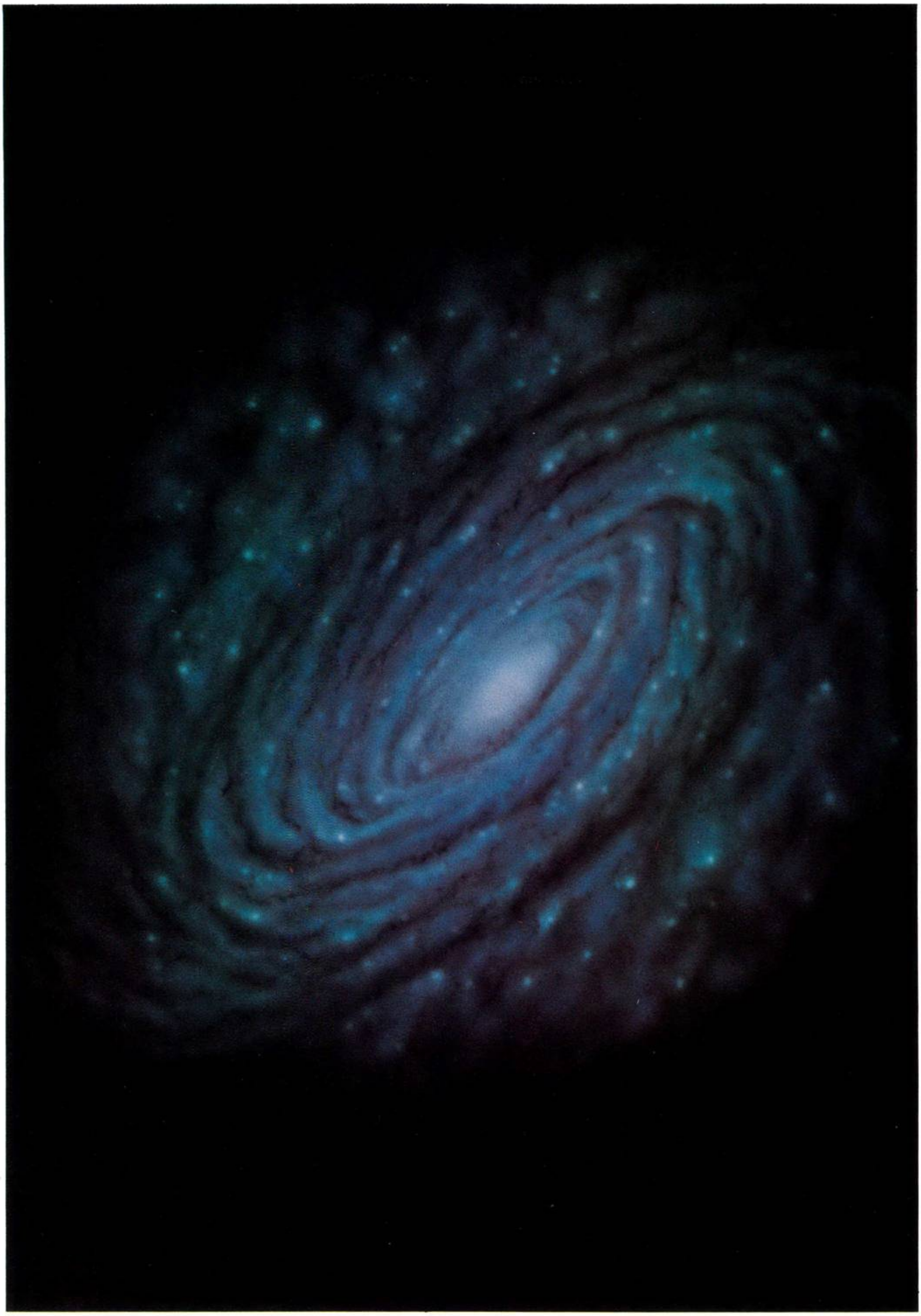
Imagine the young, radiation-dominated universe before decoupling, filled with whirls of photons and gas particles. The larger eddies contain greater than a trillion solar masses and persisted for a long time since they experienced little friction. After decoupling, they formed galaxy clusters. The fate of smaller eddies is not easily understood. However, whatever eddies survived decoupling grew quickly afterward. This development was helped by shock waves generated after decoupling. For example, large eddies could have collided and broken up from the shock waves produced in impact. The smaller blobs of matter made in the breakup then formed galaxies.

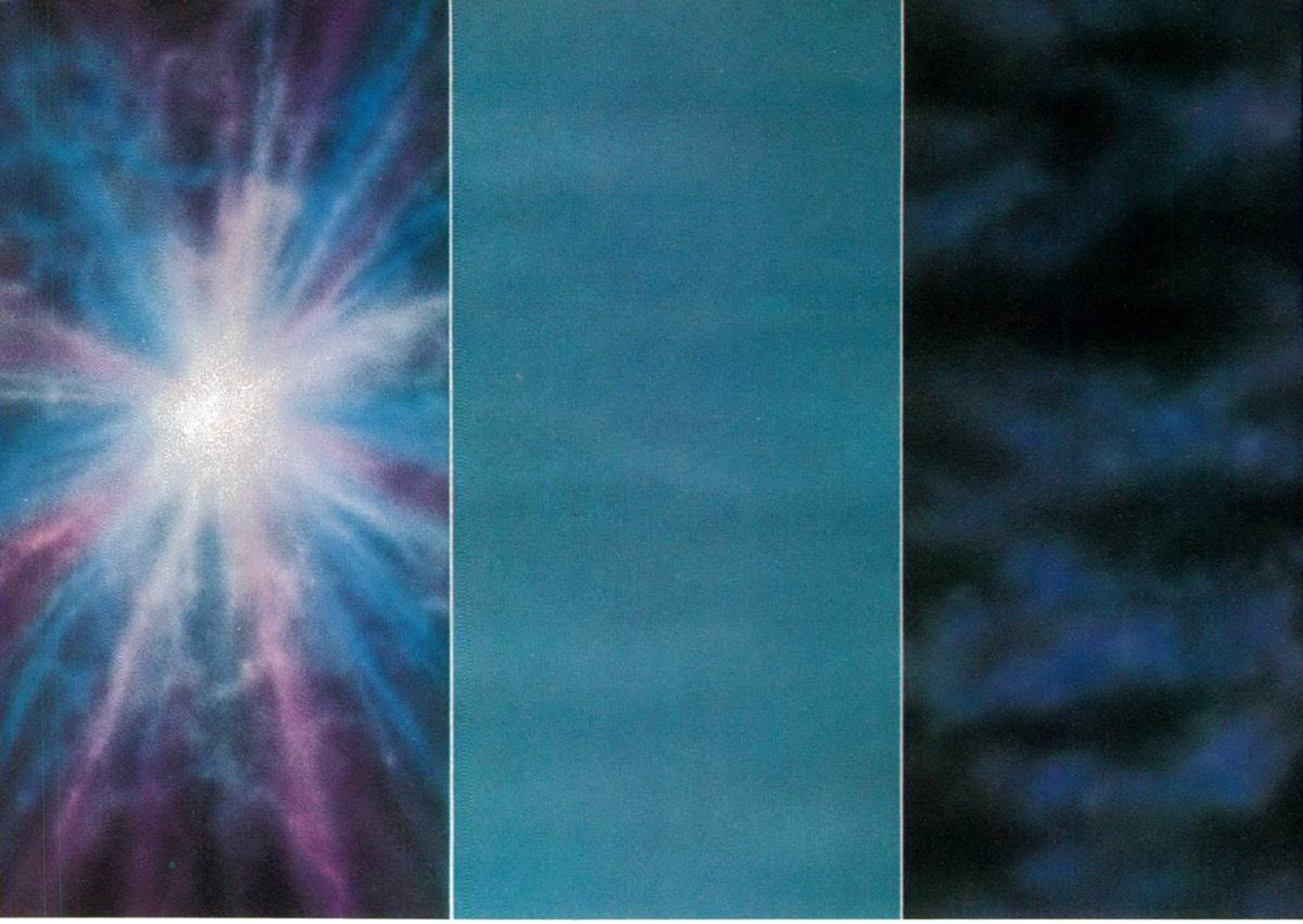
A galaxy in the process of formation, before any stars have formed in it, is called a *protogalaxy.* In time, the protogalaxy contracts and its density rises because of the continuing inward force of its own gravity. Pockets of gas continually form and dissolve in the swirling, eddying motion within the cloud. Whenever the density of one of these gas pockets is high enough, it turns into a *protostar.* The protostars contract and heat up until nuclear reactions begin at their centers, and they become stars.

When many stars have formed, the protogalaxy becomes a galaxy. As time passes, more and more of the gas from the original protogalaxy is swept up by stars. After much time has elapsed, the galaxy contains many stars with little or no gas. Throughout this process, the more massive suns undergo supernova explosions, returning some of their gaseous matter to space. But supernova debris mixes with the existing gases and is collected once more into the bodies of still more recently formed stars. Eventually, the galaxy consists of only modest sized, slow burning red stars and nothing else; no massive blue and white giant suns, no supernovae, and no gas or dust. As the last faint stars fade, the galaxy becomes a graveyard of black dwarfs, neutron stars and black holes in space. But a long time is required to reach this state. The majority of those seen are still in their prime.

The formation of a particular spiral galaxy —

Swirling eddies and turbulence characterized the proto-Milky Way galaxy. The gases, whipped into a whirlpool toward the nucleus, clearly show spiral structure in this stylized representation, but no stars have yet formed in the unstable nebulosity making up the "protospiral arms". Outside the spiral plane, galactic "halo" gases avoid capture by gravitational forces, but bright nebulosities begin forming: The birth of globular clusters (such as M-13 in Hercules) is imminent. Artwork by Victor Costanzo.





our own Milky Way — is a good example of this theory. Assume a density disturbance large enough to eventually condense into the Milky Way occurs at decoupling. At first this cloud expands with the universe, but begins to slow down. It reaches a maximum radius — about 40 kiloparsecs — and then collapses rapidly. Other clouds like this one reach a maximum size one billion years after the big bang, when their gravitational interaction causes them to start spinning slowly.

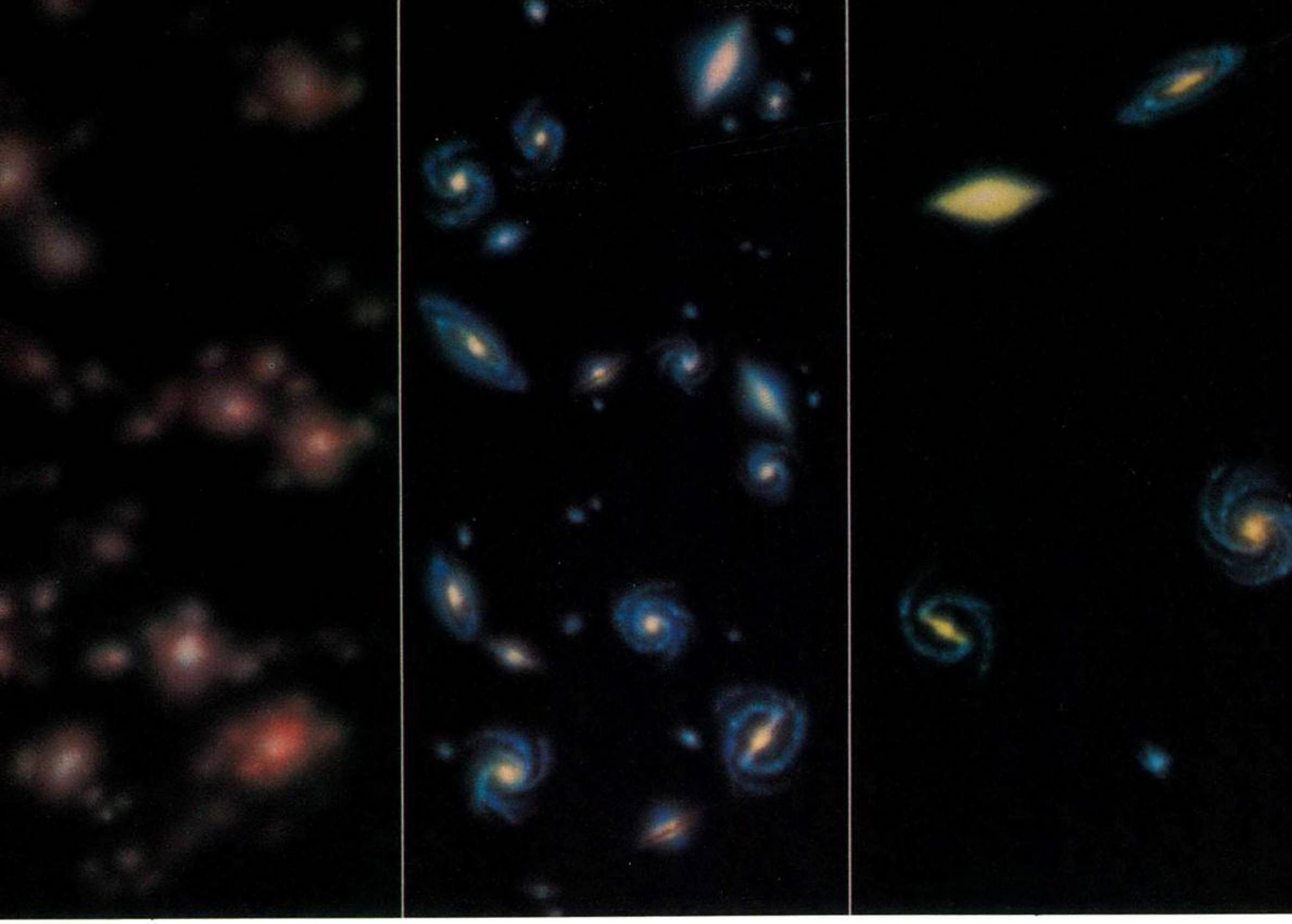
As the Milky Way cloud collapses, it spins faster and faster flattening from an originally spherical shape into a pancake. Some gas in the cloud becomes gravitationally unstable during collapse and fragments into stars. The gas not caught up in stars forms the disk of the young Milky Way.

We probably don't see any of the first stars that formed in the Milky Way. The gas was very hot when the stars formed, so to become gravitationally unstable, the fragment's mass must have been as large as several hundred suns. These massive superstars burned up very quickly on a cosmic scale — in a few million years — and then blew up as supernovae. Star birth and explosive death took place faster than the few hundred million year collapse of the Milky Way cloud disk. Demise of these suns spewed heavy elements into space (the big bang produced only hydrogen and helium) that ended up in the next generation of stars — the oldest ones we now see. New stars are still being born in the galaxy — in the Great Nebula of Orion for instance.

Galaxies resulting from the big bang are distributed beyond the Milky Way across the sky in various concentrations. When an observer looks out in space from Earth, not a single galaxy among the bright ones lies within 10 degrees of the galactic equator. This vacancy is probably the most striking feature when the general galaxy arrangement is considered. There most certainly *are* bright galaxies at low galactic latitudes, but their light is dimmed by many magnitudes because of obscuring dust and gas in and near the main plane of the Milky Way, a galaxy still rich in material for future stars.

There is no clear evidence for a major galaxy pile-up in any given part of the sky — no evidence of a dense center of the observable universe. Galactic systems lie in all directions and their numbers in any area are about the same. Their distribution is statistically *isotropic* — a fact that does not become apparent until the distribution of very faint galaxies is explored.

Pairs, triplets, small and large clusters of bright galaxies give the overall impression that they're distributed in clumps. A conspicuous example is the Virgo galaxy cluster. Another, fainter and more concentrated, is the Corona Borealis cluster



Diagramatically, the evolution of the universe is seen through these "windows" in time. The cosmic explosion producing the present visible universe appears on the left (window 1). This event occurred approximately 15 to 20 billion years ago. The universe remained opaque to its own radiation for 100,000 years after the big bang; only a bright fog was visible (windows 2). Finally, the gas cooled and became transparent to its own radiation (window 3). As it cooled, the gas became gravitationally unstable and experienced internal pressures, clumping into gravitationally bound regions. Some clumps were too small to survive the conflict between internal pressures and gravitational pull and dissipated; others survived (window 4), and began to form protogalaxies (window 5). The universe continued to expand and the galaxies to age, resulting in what we see today (window 6). Artwork by Victor Costanzo.

which contains more than 400 individual galaxies. This mammoth cluster of distant island universes, each comparable to our own Milky Way, occupies a "clump" of Earth's night sky that looks like stars, no larger than the full moon.

Galaxies also appear in four basic shapes and a vast range of sizes. American astronomer Edwin Hubble spent years studying galaxies with the 60 and 100 inch telescopes at Mount Wilson. He classified them into four major types — elliptical, spiral, barred spiral and irregular.

An *elliptical galaxy* looks like a partially flattened, luminous sphere. Some are nearly perfect spheres; others are partially flattened; still others are extremely flat like pancakes. They make up 20 percent of all galaxies, and their main property besides their shape is their old-star content. Though relatively large and massive, they are faint because they contain only these less luminous old suns. They also appear to contain very little gas and dust between stars, suggesting they are relatively old.

Fifty percent of all galaxies were classified by Hubble as spiral (a flattened disk of matter with a small spherical nucleus bulging at the center). The stars are concentrated in the central nucleus and the spiral arms radiating from the center. Because the arms are curved, the structure resembles a pinwheel, rotating far too slowly to be observed in even a year. The typical spiral galaxy, like our Milky Way, is large and massive — containing about a trillion suns (including young, middle aged and old stars).

Although most of the stars in a spiral galaxy are located in the nucleus or central disk, a small fraction — about one percent — are concentrated in globular clusters quite far out from the disk. An average spiral contains several hundred of these clusters, randomly scattered in space around the disk. This spherical volume containing the globular clusters plus a few isolated stars is called the galactic *halo*.

Globular clusters each contain one million stars packed into a beehive sphere 100 light-years in

Pairs, triplets and groups of four or more galaxies are common in galactic distribution. Though they appear scattered in concentrations across the sky, after probing deeper in space and studying the number of faint galaxies, it is obvious their numbers in any given area are about the same. Hale Observatory photograph.

diameter. It is believed that globulars were formed at a relatively early stage in galactic formation because they contain only old stars, and no gas or dust to form new ones.

About 30 percent of all galaxies are *barred spirals*. These have two arms radiating outward from a bar shaped concentration of matter. Otherwise, they are similar to ordinary spirals in every respect — the types of stars they contain, their mass and luminosity, halos, and distribution of dust and gas.

A small fraction of all galaxies known as *irregulars* do not have a clearly defined geometric form. They are relatively small, containing many bright young stars and few old ones. Frequently, they are bound gravitationally to a spiral galaxy, held captive by the spiral's massive force. The Magellanic Clouds are examples of such irregular galaxies.

New discoveries about galaxies and the big bang that created them are made almost daily. Theories evolve and are cast aside to explain the basic elements of matter in the universe. Stars, galaxies, clusters of galaxies — the universe — are a hierarchy of matter linked by evolutionary processes — all in some sense debris from a cosmic bomb that ignited billions of years ago.

Dr. Michael Zeilik is an assistant professor of astronomy at the University of New Mexico in Albuquerque. Professionally interested in cosmology for nine years, his future research will utilize infrared observations to search for young galaxies.

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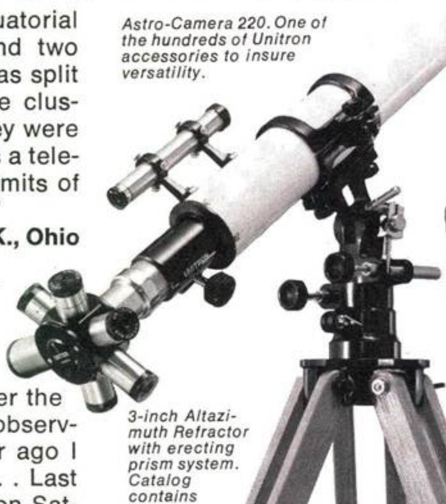

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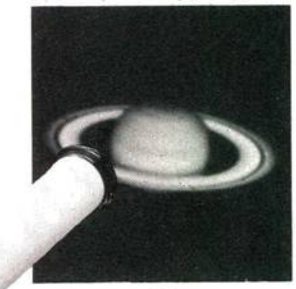
Yerkes Observatory photograph.



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UFOs Explained
by PHILIP J. KLASS

369 pages (illus.), hardcover, $8.95
Random House (1974)

Ufology is a field rampant with pretentious book titles. We've seen UFOs on the attack, revealing secrets, being unveiled, being covered up by the Air Force, and living beneath the sea. Now we have a book which claims to explain once and for all this fascinating and outrageous phenomenon of flying saucers.

It does. This is the most important book on the subject yet published. It must be read by anyone even remotely interested in the subject of unidentified flying objects.

Klass attempts to identify them with an impressive array of scientific and technological knowledge, dogged persistence, and some inspired detective work. Essentially, he says flying saucers are misinterpreted natural or man made phenomena or outright frauds.

That explanation has been presented before, but usually as an affirmation of faith, not a demonstrable fact. There always has been the "unexplained one percent" of observations which might have been interplanetary spacecraft, time machines or vacuum space creatures. Klass tackles this problem head on by picking some of the most mysterious cases of the past 25 years — cases deemed "unexplained" by eminent UFO experts and by NICAP (National Investigatory Committee on Aerial Phenomena).

The occurrences were not simple or common, or they would have been recognized as common things by witnesses. But the meticulous explanations presented by Klass (himself a pilot and radar expert) are so much more likely than the flying saucer thesis that they seem obvious. But it was only after a great deal of legwork, homework and inspiration that this man made them seem obvious.

Klass is not part of another "government coverup", if his thesis suggests it. He is an editor of the prestigious and investigative magazine **Aviation Week**, and has published earlier books on UFOs and secret government spy satellites. He is currently investigating the Bermuda Triangle controversy.

Chapter after chapter are filled with historical background — material usually severely slanted when given in most UFO literature. New information accompanies many classic cases. For example, doubt arises about the Pascagoula "kidnapping" case when the "lie detector" is revealed to have been fraudulent.

Klass cannot guarantee that his explanation is 100 percent true, nor that the flying saucer hypothesis of some sightings is 100 percent false. He does not present affidavits of fraud from some participants in "visitation" cases. But he does make a fascinating and original contractual monied offer to flying saucer believers. So far there have been no takers.

◆

Bildatlas des Sonnensystems
by BRUNO STANEK
paintings by LUDEK PESEK

202 pages, hardcover, approximately $12.00
Hallwag AG, Switzerland (1974)

With sufficient funds, an English edition of this outstanding pictorial will be forthcoming. Since it is one of the best popular works on the solar system to appear in a decade, attention now to the German volume is warranted. **Bildatlas des Sonnensystems (Picture Atlas of the Solar System)** is virtually a planetary Baedecker—Ludek Pesek's paintings treat the subjects as much from a scenic as a scientific viewpoint. Indeed, they underscore that planets of scientific interest are also visually impressive.

[Although Pesek is familiar to Americans for his paintings for **National Geographic**, he also illustrated the "coffee-table-size" volumes, **Our Planet Earth** and **The Moon and the Planets** — each containing more than 40 color paintings (both now very difficult to secure). Four slim volumes illustrated by Pesek with text by Peter Ryan — **Journey to the Planets, Planet Earth, The Ocean World,** and **UFOs and Other Worlds** — are in print from Penguin Books. He has also written and illustrated two novels: **The Earth is Near** and **The Moon Expedition.**]

With Chesley Bonestell's semiretirement, Pesek has become the leading astronomical illustrator with this work adding dimensions to his reputation. The scope runs from Earth's prehistory to the concept of the colonization of Mars. The latter half of the book is devoted entirely to Mars and includes some of his most imaginative paintings. Memorable are the panoramic views of Nix Olympica in eruption and a lava lake partially filling the caldera of North Spot.

Bildatlas is a large, handsomely designed book, with the majority of the nearly 40 color illustrations reproduced as double-page spreads. The text is supplemented with diagrams and photographs.

Even if the reader is not familiar with the German language, the visual excellence of this volume supports the price.

◆

For All Mankind: America's Space Program of the 1970s and Beyond
by L. B. TAYLOR JR.

307 pages, hardcover, $8.95
E. P. Dutton and Company (1974)

As America shifts gears from its Apollo manned space efforts and the revolutionary Space Shuttle, many observers are summing up our country's accomplishments in space and forecasting future developments.

Remote sensing of resources, technological spinoffs, and future benefits in improving everyday life on Earth are covered in extremely fine detail in **For All Mankind**.

However, the rest of the book is very weak. The closer the author gets to astronomy — either orbital telescopes or planetary probes — the more superficial and sloppy the text becomes. Research on these sections is obviously far below the higher standards of the rest of the material.

Taylor utilizes many quotations as backbone for his chapters — but often gets carried away, using the same quotation twice or using mutually contradictory quotations only a few pages apart. His own words tend to become overly complex. (What does it really mean to say that "Jupiter could swallow up 1,300 Earths"?)

Arthur Clarke is a writer, not an astrophysicist. Tsiolkovsky was a Russian spaceflight theoretician, not a Soviet space scientist. These and other small but disturbing errors of fact are regrettable, as the author often loses sight of petty detail while trying to give the "liberating perspective of space". The results are a flawed but still occasionally useful book on uses of space.

◆

Space Shuttle

by SPACE SHUTTLE PROGRAM OFFICE

77 pages (illus.), paperback, free*
NASA (1975)

Everyone seems to have heard about the Space Shuttle, but not even NASA knew many of the engineering details until recently. Vital factors such as crew size, living quarters arrangement, flight profiles into and back from space, and preflight vehicle transportation were still unsettled as late as a year ago.

Now things have firmed up, and this report is the first detailed NASA description of the resulting designs for the next American spaceship. Although somewhat disorganized, the booklet provides an excellent in-depth account of the Space Shuttle's appearance and construction.

One hundred tables and illustrations provide more than enough detail for the most intricate model spacecraft builder. Mission profiles and engineering subsystems are graphically portrayed. Information this precise and complete has never before been available to the general public.

Fifteen pages are devoted to "Space in Everyday Living", but little mention is made of the scientific research (as opposed to applications) to be carried out in space. A cogent closing essay stresses the project's economic impact, and the book ends with a 13 page list of the names, assignments, and home states of the major Space Shuttle contractors.

In fact, it seems that the publication was primarily intended to persuade people (mainly congressmen) to support the manned space program. In this effort, technology — not science — is emphasized. Although not entirely satisfactory to most scientists, the main theme remains valid: "...technological advance is the primary source of higher productivity and economic growth, and (space) research and development is the chief contributor to technology." The role of basic scientific research such as the large space telescope or the Spacelab module is ignored, leaving an incomplete view of the Space Shuttle project. Nevertheless, the engineering details are excellent, and the message is urgent: We need the Space Shuttle. The reasons given are well presented and valid, and provide potent ammunition to the continuing debate over the project.

** Stock number #1975-671-199/1608. Available on request from the NASA-JSC Public Affairs Office, Houston, TX 77058.*

◆

Francis Place and the Early History of the Greenwich Observatory

by DEREK HOWSE

64 pages, hardcover, $12.95
Science History Publications (1975)

As head of the National Maritime Museum's astronomy department, Derek Howse is responsible for the extensive astronomical collection housed in the old Royal Observatory in London's Greenwich Park. This year the observatory celebrates its tercentenary, and Howse has put together the material in **Francis Place and the Early History of the Greenwich Observatory** to commemorate the event. The strange juxtaposition in the title of an obscure 17th century artist and what Howse calls "Britain's oldest scientific institution" (although he surely knows that the Royal Society of London is a few years older) suggests the quaintness of this expensive little souvenir.

The book's main subject, barely hinted at by its title, is a rare set of 12 etchings executed by Francis Place to mark the opening of the Royal Observatory in 1676. The handsomely reproduced etchings include a map, a plan, and various views of the original observatory in its Greenwich Park setting as well as several views of its interior and the original instruments. With the informative notes provided by Howse, the plates offer glimpses of the early observatory and its work.

Beyond the random insights of the annotated plates, the early history of the observatory promised in the title is limited to a brief, scholarly essay on its foundation. Howse outlines the 17th century problem of determining longitude at sea and tells of Charles II's appointment of John Flamsteed as first Astronomer Royal — "to rectifying the tables of the Motions of the Heavens and the places of the fixed Stars so as to find out the so-much-desired Longitude of Places." To facilitate Flamsteed's work, the king ordered Sir Christopher Wren to design "a small Observatory within our Park at Greenwich". Flamsteed, assisted by Edmond Halley, put the final touches to the new instruments and recorded the first observations on Sept. 16, 1976.

While Howse has compiled many little-known facts about the foundation and construction of the observatory, a more general overview would have helped the reader relate the Place etchings to the early work of the observatory. Instead, the essay on the observatory's foundation is followed by a detailed account of the little that is known about Franics Place, Robert Thacker (the equally obscure artist upon whose drawings Place's etchings are based), and the history of the etchings themselves. Much of Howse's writing suffers from a pedantic concern with such details as which of Place's etchings were published with which editions of **Historia Coelestis Britannica** (the great star catalogue prepared from Flamstead's Greenwich observations).

Howse has put together a very special volume — so special that it is difficult to decide for whom it was compiled. A somewhat disjointed scholarly monograph of interest to science and art historians is expensively presented as a gift book for a more general audience interested in the early days of the famous observatory. By placing so much emphasis on research into the background of the Place prints, Howse misses an excellent opportunity to elaborate on the importance of the period of modern astronomy which they illustrate — a period when the finishing touches were being put to the mechanical view of the universe which still prevails in many minds. Similarly, his narrow view of the foundation of the observatory fails to communicate the excitement that must have surrounded the creation of Europe's second national observatory at the height of the 17th century's space race. The chief value of the etchings lies in their subject matter — the actual structure and working equipment of the Royal Observatory. The chief value of the observatory is its historical position as one of the first national institutions devoted to man's discovery of his place in the universe. A book promising the early history of the Greenwich Observatory owes us a greater appreciation for these values than Howse has shown.

◆

MARS' NEW FRONTIERS

by

William Hartmann

Ideas and speculation about Mars have come a long way since Sir William Herschel suggested in 1784 that Mars' polar caps were ice and snow, and that it must have life "in many respects similar to our own". Later it became a world of seas and oceans, a globe crisscrossed with canals built by intelligent life, and finally (with photographic views returned by the Mariner mission series) a planet of tangled mountains, giant craters (far larger than on our moon), mammoth canyons, volcanos and ridges. It seems a forbidding place, impersonal and apparently dead — no lakes, rivers, seas or canals; no Martian cities or great manufacturing centers.

But the Mariner craft viewed Mars from 2,000 miles above the surface. A true concept of the landscape found there could not really be felt. Only a land based look can fulfill that concept.

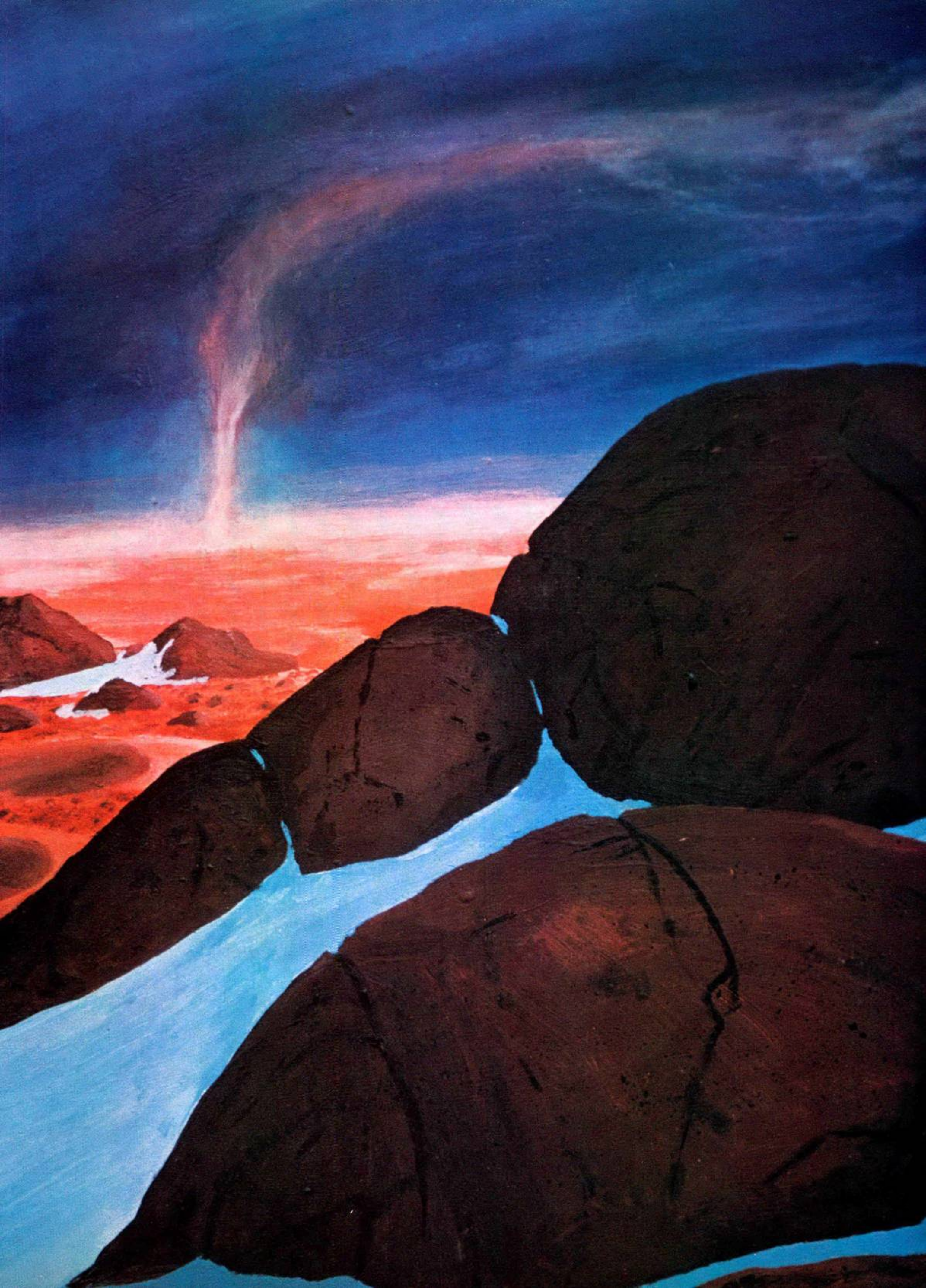
What will the Martian terrain be like? What vistas will a visitor to Mars see on the lonely and often hostile surface of a planet named for the Roman god of war? Prediction and speculation about the environment on Mars may aid in understanding and interpreting what will ultimately be seen.

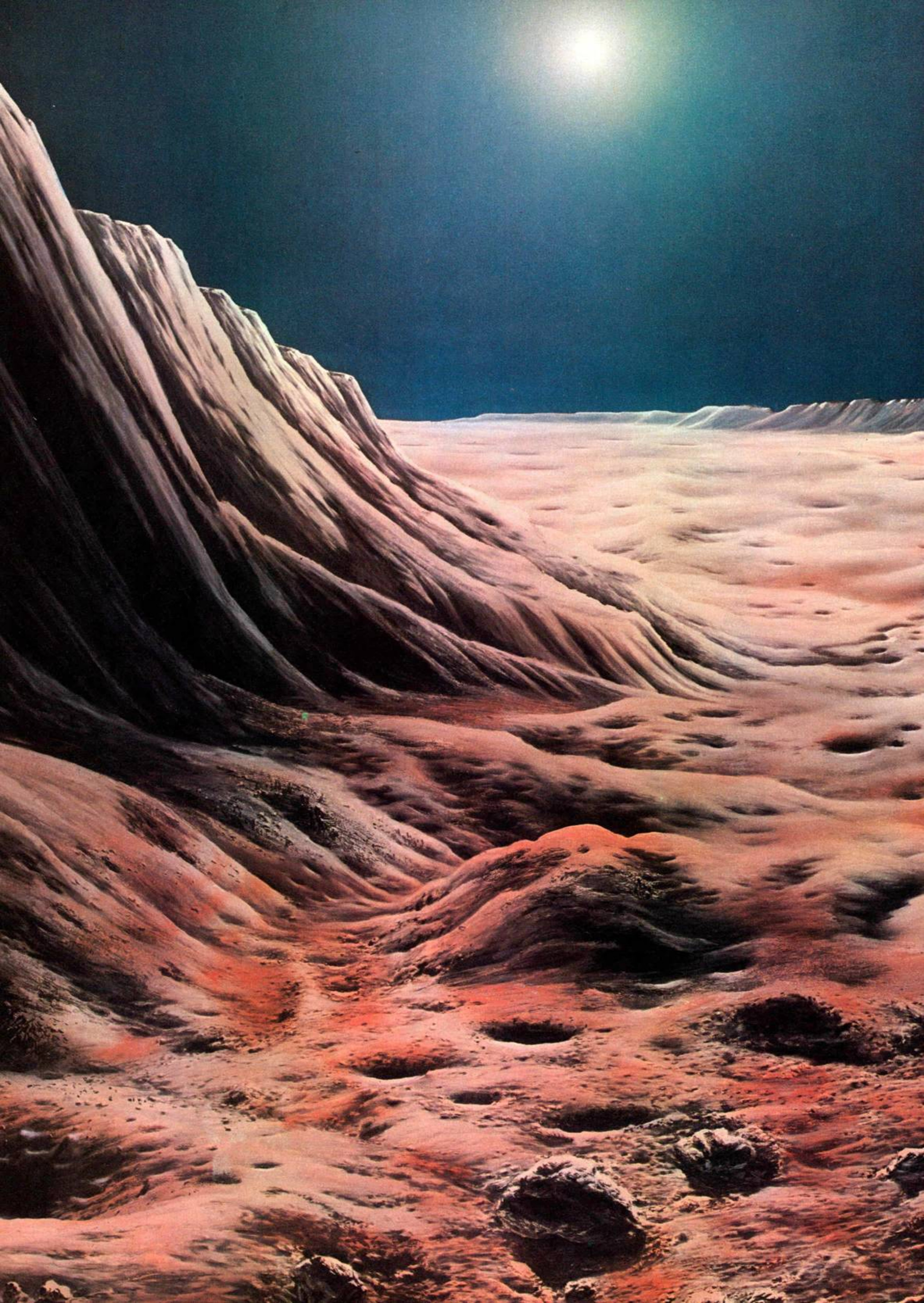
An interesting array of information aids the accuracy of speculation about the Martian environment — telescopic observations, photographs from spacecraft near the planet and studies of terrestrial regions believed to resemble Mars.

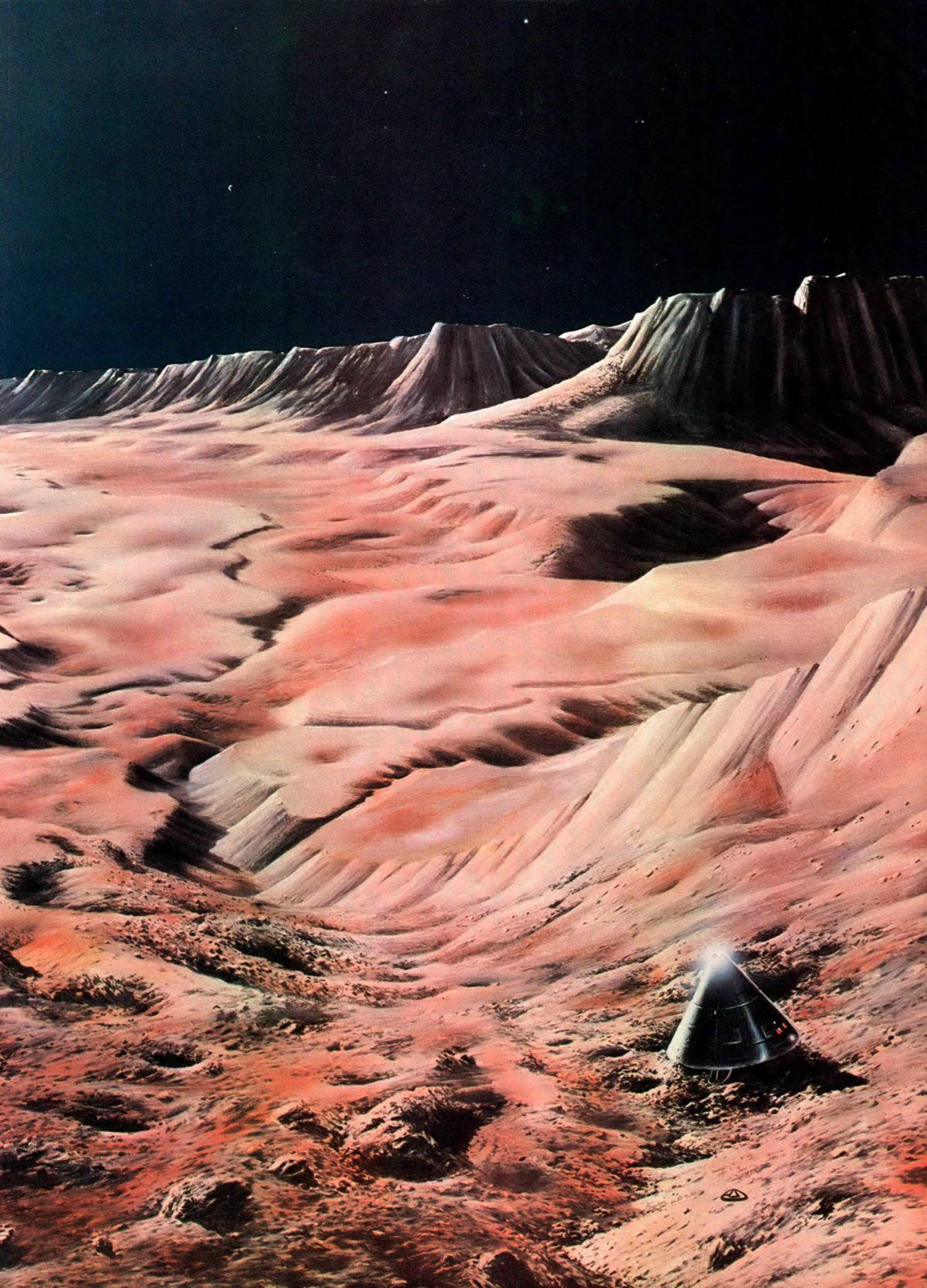
It is known that in most regions on the Martian surface, the total air pressure and density are less than one percent of the values on Earth's surface (similar to air pressure 100,000 feet above Earth — three times the altitude of typical commercial jet flights). In many high regions of Mars the total atmospheric pressure is less than 6.0 millibars; at such values, liquid water cannot exist in any appreciable amounts. On Mars' warmest afternoons in low latitudes, the red planet's soil temperature can exceed 32 degrees Fahrenheit; it occasionally reaches levels as high as 50 to 70 degrees Fahrenheit, but this is exceptional. Usually the temperature is below freezing, and plunges far below zero at night. Spectroscopic observations show hardly any water vapor in the atmosphere. (If all the water in the Martian atmosphere precipitated onto the ground, it would form only a microscopic layer about 20 microns deep!) Although liquid water may have existed in the past on Mars (forming the mysterious river-like channels photographed by Mariner 9), any water on the planet today must be hidden in icy deposits beneath the soil, chemical constituents in Martian minerals, or ice deposits in polar snowfields.

The small, permanent polar caps left in summer after the disappearance of the large seasonal caps are widely believed to be frozen water. In 1973, Cornel observer J. R. Houck reported definite spec-

A dust devil ravages the Martian flatlands, swirling into the deep blue Martian sky. This artist's conception depicts what the Martian surface may look like to an Earthborn observer on the first visit to the red planet. Artwork by William Hartmann.







tral evidence that Martian soil contains about one percent *bound water* — a term referring to water physically trapped and chemically compounded in soil minerals. But water or water vapor from such sources never accumulates in the atmosphere or on the surface in appreciable amounts under present cold conditions.

At the outset, a terrestrial visitor faces an arid, cold planet, and would need protection against a harsh and inhospitable environment.

The Martian sky might be very dark (deep violet blue) because of the thin atmosphere. But this would be true only if the air is very clear, and this does not appear to be the case. Low angle, long vista photographs from the days of Mariner 4 onward reveal indistinct horizon details because of the heavy concentration of dust in the Martian atmosphere. Dust sometimes reaches 100,000 feet above the surface, and can make the Martian sky nearly opaque. Visitors to Mars could expect the horizon to be hazy and ill defined due to blowing dust. And overhead, on some days, dust may make the otherwise deep violet blue sky much lighter — possibly approaching the color of Earth's sky. White or bluish clouds (similar to cirrus clouds on Earth) frequently form at high latitudes near steep mountains or slopes and occasionally may be visible overhead.

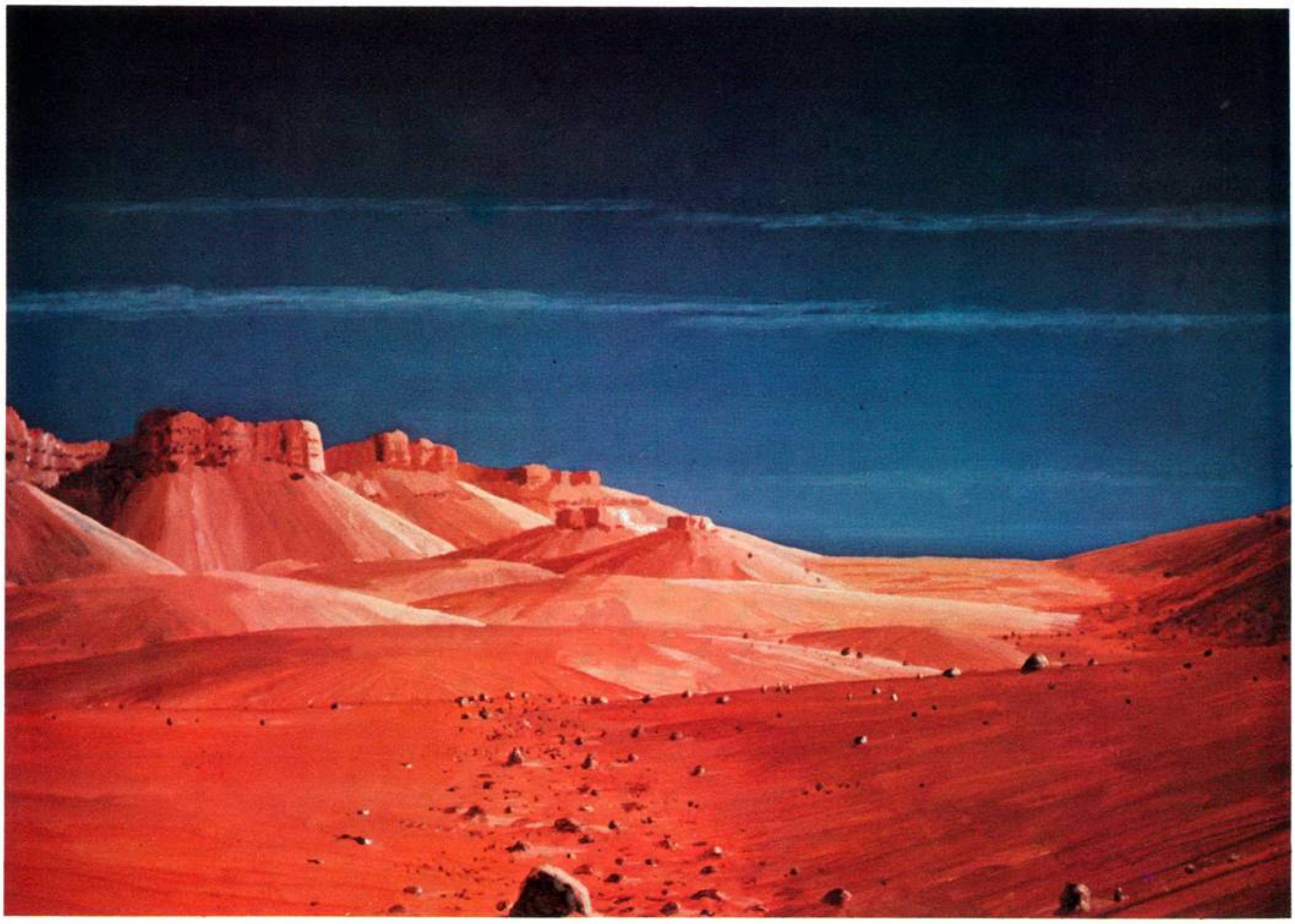
It may be foolish to describe a "typical" Martian landscape. After all, what is a typical landscape on Earth? Rolling hills, cliffs, mountains or vegetation? The best description is an open expanse of water. It might be similarly risky to characterize the typical Martian scene.

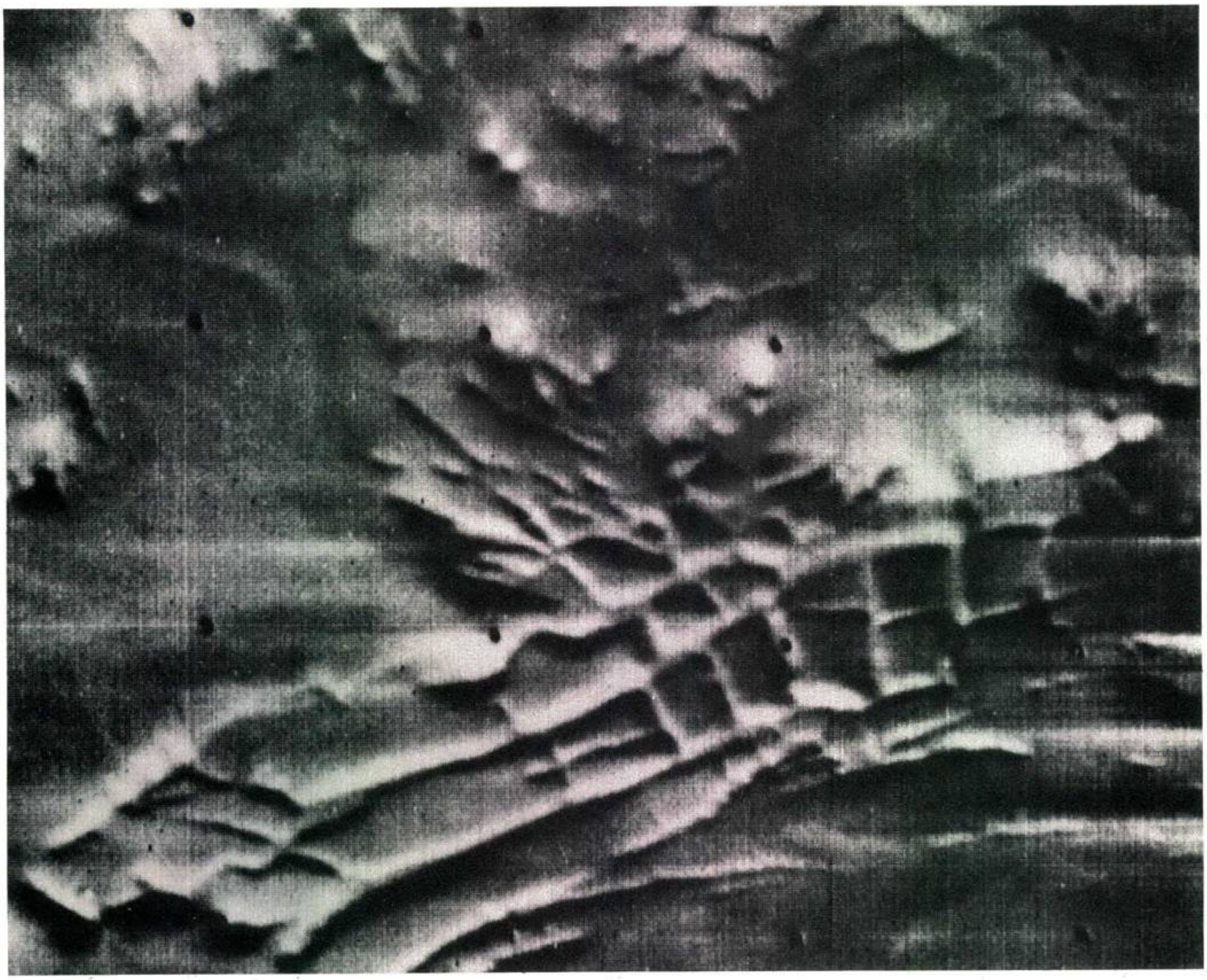
Landscapes at the polar caps, the summit of the Olympus Mons volcano, the great Vallis Marinaris or other selected regions could reveal wide differences. But 100 randomly selected spots on Mars would show some similarities. Martian soil is generally orangish to reddish brown in color. That much can be seen by any observer on Earth with a 2.4 inch telescope. Spacecraft observations strongly indicate that loose surface deposits have been shaped by the winds; the dust frequently

Caption for Page 20

The vast Valles Marineris, sometimes called Mars' Grand Canyon, stretches off into a pale sun as viewed by a future Earth expedition from a landing base on the rim. This incredible tear in the Martian surface extends 2,500 miles along the equator, reaching widths up to 150 miles and depths up to four miles. Artwork by Adolf Schaller.

Faults slashing the Martian surface caused great valleys to form in the planet in some areas as seen in this artist's interpretation. The high, icy clouds in the blue-violet Martian sky and the contrast of the vivid red terrain offer a colorful view of this distant world. Artwork by William Hartmann.





This Mariner 9 photo reveals some of the startling and intriguing aspects of the Martian surface. Complex patterns near the Martian south pole are ridges two to five miles apart composed of more resistant material than the surrounding soils. The material probably filled the cross-cutting features and was later exposed by erosion. Intruded molten rock could have filled the faults, or dust could have blown into crevasses in an ancient ice mass on the planet. Jet Propulsion Laboratory photograph.

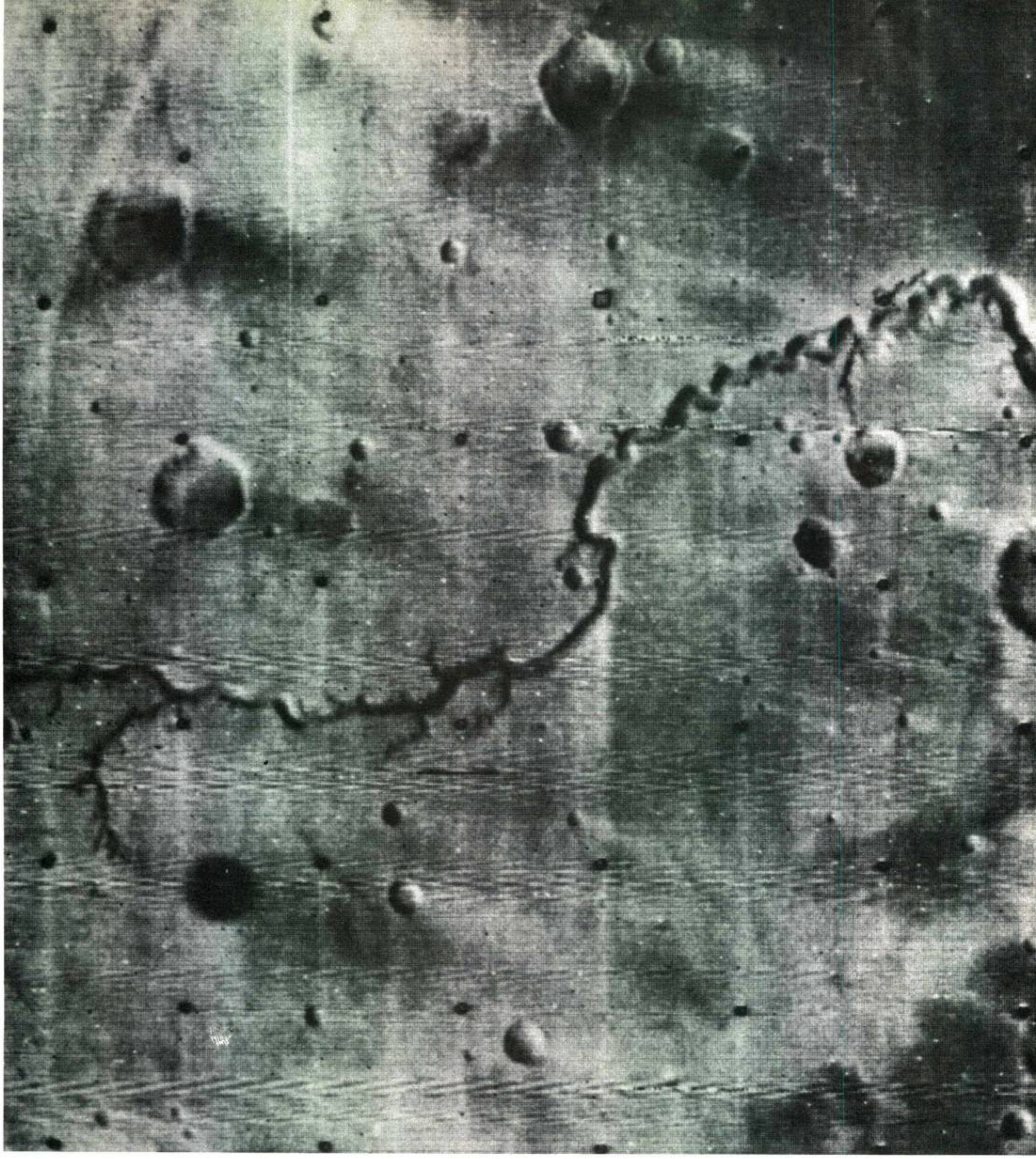
swirled into Mars' atmosphere is very fine — similar to flour.

Estimates of wind needed to raise dust range from about 120 m.p.h. to as high as 250 m.p.h. But to put these into perspective, the wind on Mars at the same speed would be 10 times less effective than the same wind on Earth because the density of the atmosphere is 100 times less. A 200 m.p.h. wind on Mars would be like a 20 m.p.h. wind on Earth.

Besides fine dust, coarser granular material must exist on the surface. Some regions would have a sandy texture, scattered with rocks. If rock is exposed in cliffs or rugged outcrops, some regions may be subject to erosion and provide a fresh dust supply, transported by the wind and deposited elsewhere. This could explain why some Martian regions remain dark or bright even though the wind tends to mix the loose powdery soils. For example, dark areas may have fresh rock exposed. Massachusetts Institute of Technology experimenter Robert L. Huguenin has shown how fresh grains of iron bearing minerals (such as magnetite), broken from rock outcrops, eventually become weathered and coated with iron oxide minerals (such as reddish hematite). Hematite, being mechanically weak, weathers away from the surface and adds powdery red dust on Mars.

In some regions (such as the flanks of the huge volcano Olympus Mons), Mariner 9 photos show lava flow structure; lava rocks are either exposed at the surface or covered by not more than a few feet of dust.

Desert pavement — an interesting phenomenon of terrestrial deserts — probably occurs on Mars' surface as well, formed in areas where dust or sand and scattered rocks are mixed. As the dust is removed by erosion, the rocks are left behind on the surface — too large to be carried by the wind. Over a period of time, surface rocks are exposed in large numbers and packed edge to edge. They create a protective cover over underlying dust, preventing



Twisting sinuously across the Martian plains, a valley 250 miles long and 3 to 3-1/2 miles wide was photographed by Mariner 9 during the spacecraft's 133rd revolution of the planet. The feature resembles a giant version of an Earth "arroyo" — a watercut gully found frequently in the mountains of southwestern United States. Jet Propulsion Laboratory photograph.

further erosion. If the local rocks are similar in size they create *a mosaic* resembling paving stones. This may cause the region to thrust above surrounding unprotected areas that are still being eroded. Desert pavement seems to occur near some volcanic Martian craters that have thrown out layers of rubbly ejecta (material thrown out by a volcano) called *ejecta blankets*. Mariner photographs reveal some of these ejecta blankets standing out in bold relief, apparently many yards above the surrounding desert. The crater has probably ejected a layer of broken rock and after an erosional period, this rock has been left as a protective layer of desert pavement, preventing further erosion of the ejecta blanket.

Many of the most spectacular Martian landforms photographed by Mariner 9 are so huge they would not be prominent to an observer on the surface. Olympus Mons (15 miles high and over 350

miles across its base) or the canyons of the Vallis Marinaris (extending 2,500 miles along the equator), and many craters as well, are comparable in size to whole states in the United States. They could not be perceived by a ground observer as structural units.

Many rugged areas probably exist — open cracks or faults producing jagged cliffs. But examination of the highest resolution Mariner photos shows most areas would exhibit modestly rolling or smooth landscapes. So much erosion and deposition has occurred that mile-wide or smaller craters, while more common than on Earth, are still relatively infrequent, and meteorite craters are not as noticeable as on the moon. The landscape must be rolling, with distant hills or cliffs, scattered rocks and dusty deposits.

Wind has been very important in shaping the Martian terrain. Proof of the wind's capacity to create dramatic landforms is the presence of massive dune fields on Mars. These dune fields are often on the floors of craters where dust accumulates, blown over the rim by high winds. Some fields include individual dunes hundreds of yards high with separations of a mile or more. Mariner photographs show long, streaky markings on the leeward side of craters and hills in regions of strong prevailing winds. These markings reveal deposition of dust or erosive scouring in areas where wind flow is disturbed by obstacles, such as crater rims. Similar features can be found in terrestrial deserts. By analogy with such deserts it is fairly certain an observer on the surface of Mars would see wind-created landforms ranging from linear streaks and ripples a few inches in size to massive landforms so large no perception of them from a single location would be possible.

An average sized feature like this is the *yardang*. This sharp ridged hill resembles the hull of an inverted rowboat; the fluid wind and wind-driven sand erode the hill until its shape becomes streamlined and allows the wind to pass with least resistance. Any resisting projections are worn away during the years. (Yardangs have been seen in high resolution Mariner 9 photographs.)

Terrestrial deserts are probably good guides to Martian landscape features. Satellite photos of Earth compared with photos taken of Mars in recent years reveal the Martian deserts are only moderately beyond terrestrial desert landform experience. The deserts of Saudi Arabia, the Peruvian coast and even the extreme southwestern U.S. all show wind-blown dusty streaks, dune fields, dry channels with stubby tributaries and fluted cliff faces typical of features found on Mars.

The community of planetary scientists has some idea of what Mars will look like, and why it looks that way. Next year, if one or both Vikings are successful, or if Soviet scientists succeed in their attempts to land a vehicle on Mars, pictures may record the Martian terrain for scientific study and the satisfaction of human curiosity. They may show something entirely different from the predicted dusty plains, scattered rocks and rolling hills. But chances are good the spectacular vistas of Mars will reveal themselves as just that — spectacular vistas from another world other than Earth, but nevertheless similar to those found here.

Dr. William Hartmann is a senior scientist at the Planetary Science Institute in Tucson, Ariz., and currently serves as a visiting professor of astronomy at the University of Hawaii in Honolulu. He is author of the introductory text, ***Moons and Planets*** *(Wadsworth Publishing Co., 1972), and co-author of* ***The New Mars****, an illustrated NASA account of the Mariner 9 mission.*

GAZER'S GAZETTE

FIND A COMET

by

Frank Apsi

Comet hunting is one of the few areas in which astronomy enthusiasts can make significant contributions to science. The professional astronomer simply doesn't have time allotted to search for new comets. In fact, many of the telescopes used by professionals are not suited for comet seeking.

When comets first come within visual range, they appear quite faint and nebulous — just a fragile patch of light. If a spectacular tail develops at all, it forms weeks or months later as the comet approaches the sun.

Most visual comet discoveries have been made with telescopes between four and eight inches aperture, with magnifications varying from 25 to 40 power. Low magnifications are essential since comets are diffuse and difficult to detect under high power. A wide field — typically between one and three degrees — is a must, and low power provides a large field of view so a bigger area of the sky can be scanned. The important characteristics of a comet telescope are good light gathering power and wide field of view.

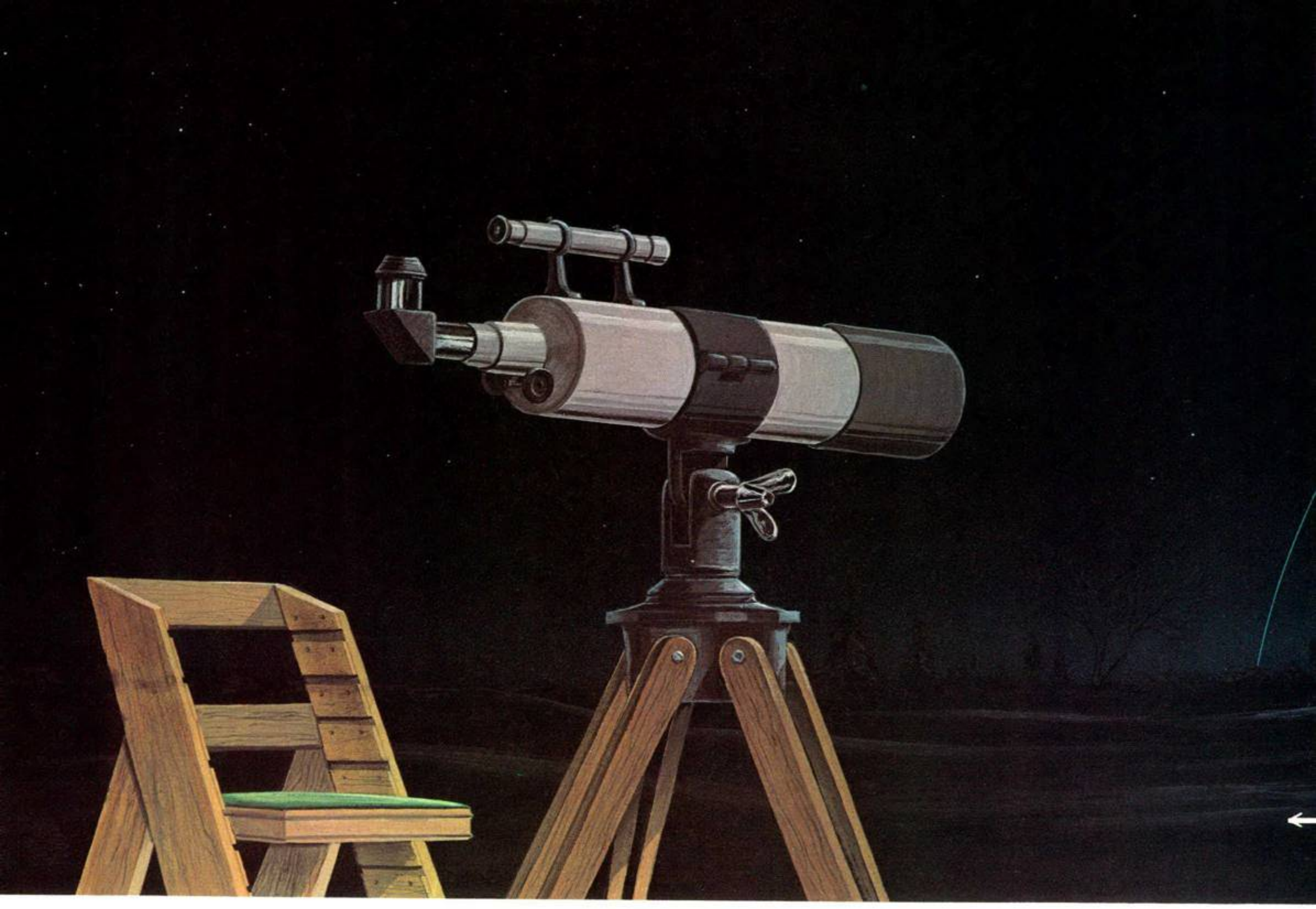
Richest-field telescopes (RFT) — both reflectors and refractors — are the comet hunter's most effective tool. The secret is large aperture — four inches or more — combined with short focal length, resulting in a fast optical system (f/4 to f/6).

Traditionally, RFTs have been of the classical Newtonian reflector design like those sold by Cave Optical Co., Superior Optics, Star-Liner and others. These instruments provide comet seekers with superb, wide-angle views of the sky economically. Seldom explored by most astronomy enthusiasts are the equally useful RFT refractors for comet hunting. Large aperture binoculars fit this category, although they are considerably more expensive than RFT reflectors.

(Would ASTRONOMY readers like to build an RFT refractor? You can, and it's not that difficult to do. If you'd like an Equipment Atlas article on building a richest-field refractor telescope we'd be pleased to oblige you! Just write to The Editors, ASTRONOMY Magazine, 757 N. Broadway, Suite 204, Milwaukee, Wisc. 53202.)

Altazimuth mounts are better for comet hunting than equatorial mounts because they eliminate awkward sweeping of the skies experienced with an

Finding a comet like 1975h (Kobayashi-Berger-Milon) that appeared recently in late summer skies can be an enjoyable and challenging observing project. On Aug. 8, the comet was below the handle of the Big Dipper, captured here on High Speed Ektachrome exposed for 30 minutes with home built 16 inch, f/6 Newtonian reflector and cooled emulsion camera. Photograph by Orien A. Ernest.



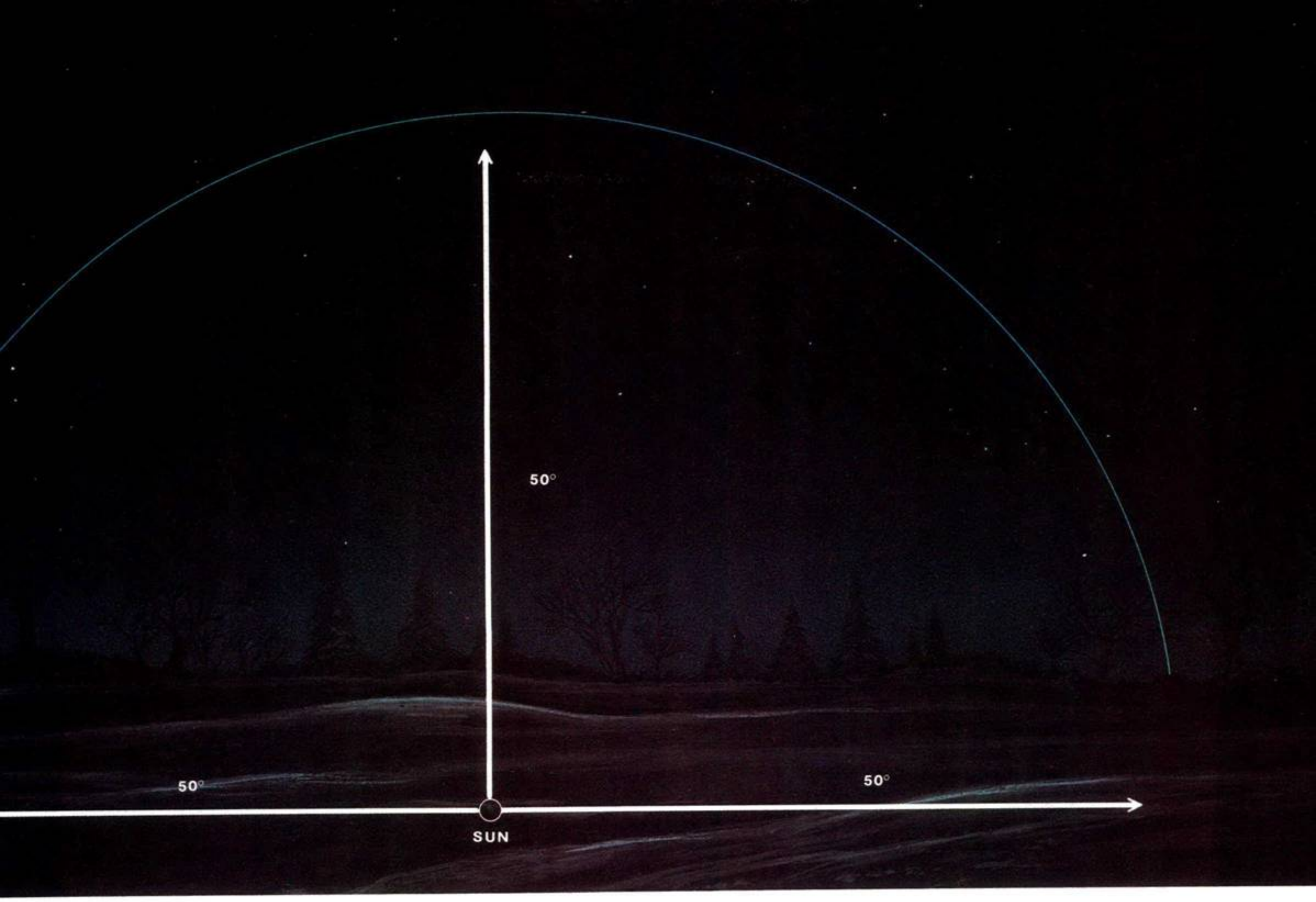
Richest field refractors on altazimuth mounts (like the one shown here) serve well for comet seeking. An adjustable chair and eyepiece diagonal add to observing comfort when comet hunting, because a serious comet hunter will spend between two and four hours a day scanning the "comet haystack" (indicated by the arc in the drawing). When scanning the comet haystack in the evening, begin at the horizon just after sunset, pointing your telescope 50 degrees to the right or left of the sunset point. Slowly sweep through the sunset point and 50 degrees beyond it. Keep repeating this procedure until you reach 50 degrees above the horizon. Reverse the procedure to sweep the morning haystack, beginning 50 degrees above the horizon and sweeping down to it. Artwork by Victor Costanzo.

equatorial. The altazimuth mount allows more natural horizontal and vertical movement in searching for comets.

Almost expert knowledge of the night sky is needed to hunt the heavens populated with cometlike nebulous objects. This profusion includes external galaxies, planetary nebulae, star clusters, gas clouds and faint, close double stars. (Incidentally, other types of observing provide excellent training for budding comet hunters. Critical deep sky observing especially may reward you with the discovery of a comet. Not only will you become more familiar with those cometlike nebulosities that abound, but sweeping the skies for known nebulosity at fainter and fainter magnitudes trains your eye to see even dimmer objects.) So if you don't know the night sky, comet seeking can help your observing skills in a relatively short time.

With all the nebulous objects lurking about ready to deceive any potential comet hunter, a good star atlas is an absolute must. (Needless to say, it would be embarassing to report that M-1 — the Crab nebula — is a new comet.) In addition, serious comet hunters should subscribe to the International Astronomical Union (IAU) circulars. These "quick response" cards come from the Smithsonian Astrophysical Observatory, Cambridge, Mass., and contain not only information on newly discovered and periodic comets, but news about novae, variable stars and other celestial events. A regular subscription costs $25 per year, covering all cards issued during that time. (For more information write the Central Bureau for Astronomical Telegrams, International Astrophysical Union, Smithsonian Astrophysical Observatory, Cambridge, Mass. 02138.)

Several sky areas are troublesome to the comet hunter because they contain so many faint galaxies. The better part of an evening could be spent just figuring out their identities. In some parts of Canes Venatici, Coma Berenices, Ursa Major and Virgo, three or four of these faint galaxies can be seen in a single field of view at low power. To save time and keep peace of mind, avoid these areas. If you're a beginning hunter, get a pretty fair idea of what an average comet looks like when first discovered. Just sweep your telescope through the western



portion of Virgo. One particularly cometlike object in the constellation is an 11th magnitude galaxy listed as NGC-4570. An even easier test is M-97 (the Owl nebula) in Ursa Major. If you can find these objects easily on a clear moonless night, both your eye and your telescope are ready for comet seeking.

Each newly found comet is named after its discoverer (up to three names may be attached to a comet if it is found simultaneously). The lucky discoverer may suddenly find national or even international notoriety as his name decorates the evening sky. When asked why he hunted comets, Karou Ikeya, a noted Japanese comet hunter, replied: "To write my name across the sky."

As a successful comet hunter you too could find your name permanently registered in scientific history. Comet Kohoutek, when it returns 75,000 years from now, will be a celestial monument to the man who first detected it. Once identified, a comet never loses its original discoverer's name.

Tricks of the Hunt

Searching for these elusive objects takes many hours at your telescope's eyepiece, so make every effort to be comfortable. Reduce eyestrain with an eyepatch over your "untrained" eye (the eye not used for observing).

Take whatever steps are necessary to avoid awkward observing positions. Use an adjustable chair (a bar stool works well — it can be adjusted to different heights), or a ladder. The ladder allows you to switch steps and change your observing position easily as you sweep higher or lower in the sky. Some comet hunters kneel on blankets or soft pads. Many dedicated hunters deliberately cut down their telescope tripods so they can use this position. In any case, be comfortable and avoid neck strain. Any discomfort you feel by tilting your head back unnaturally causes some loss of light grasp and resolution in your eyes, and any light loss is critical when you're comet hunting.

Add to your comet telescope a light shield — a cylindrical shell (like a rolled desktop ink blotter) that slips over the sky end of your telescope. The shell should extend at least six inches beyond the end of the tube to keep stray light from entering the scope. Most of all, the light shield improves the contrast between a "new" comet and the sky background. As an added bonus, the shield slows dew formation on your telescope's optical surfaces by offering a large condensation area for air moisture.

Comets brighten considerably as they near the sun. Consequently, most comet finds occur in a circular area around the sun of about 100 degrees. Some active comet hunters call this region the *comet haystack.*

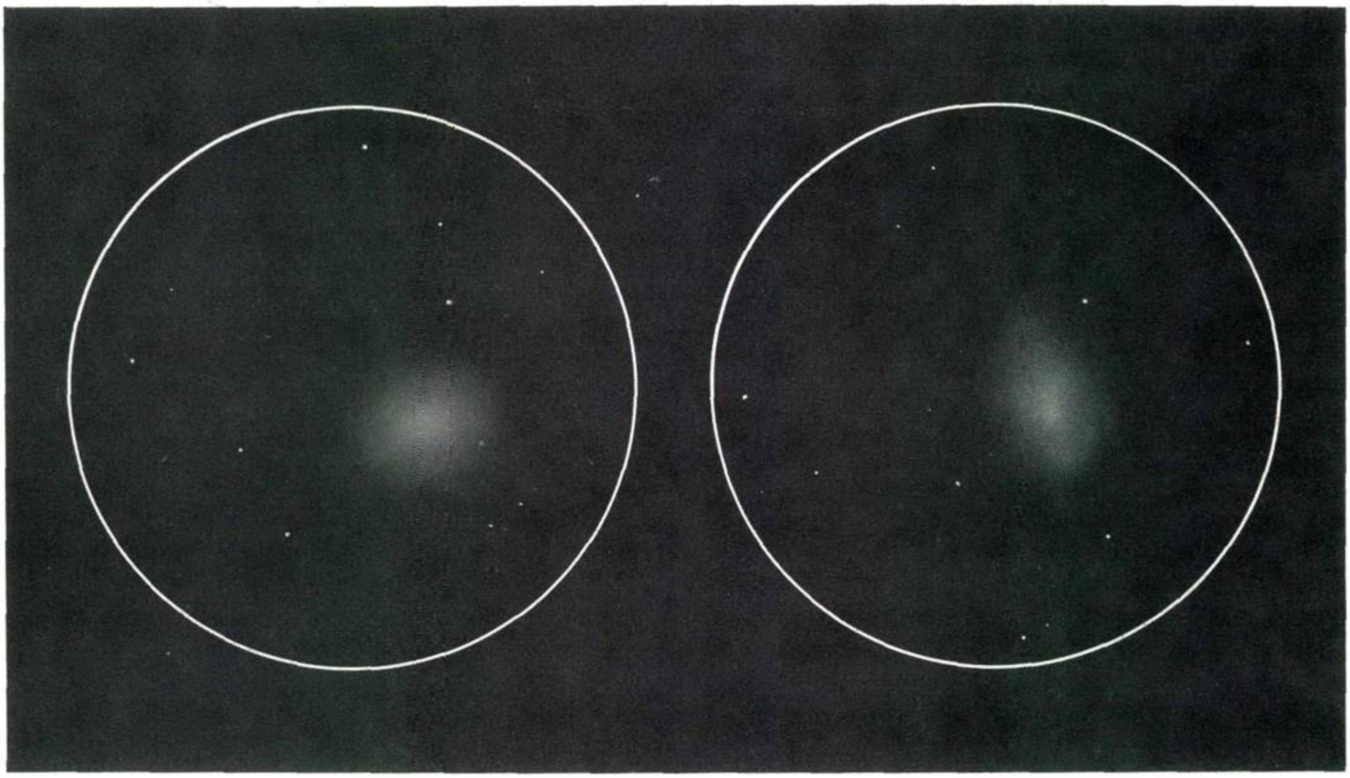
Searching the haystack for comets is really quite simple (finding one is, of course, another matter). Set up your telescope in the early evening, just after twilight, facing the western horizon. You don't need to polar align it — just aim it 50 degrees to the right or left of the sunset point and at the horizon. Slowly move the telescope through the sunset point to a position 50 degrees beyond it — an azimuth sweep of 100 degrees. Your azimuth sweep rate should vary with your equipment and personal preference; generally staying within the range of 1/2 to 1 degree per second works best. Raise the telescope by 1/2 your field diameter, overlapping a little the area you just covered; then sweep slowly back to the starting position. Keep repeating this until you reach about 50 degrees above the horizon. At this rate it should take between one and two hours to completely cover the haystack region.

In the morning, reverse the procedure — sweeping the eastern sky with the onset of twilight, starting 50 degrees above, and working down to the horizon. If you sweep both the morning and evening haystack, you could spend about four hours per day — a considerable amount of time! More comets are found during the morning hours, so if you're selective, the morning haystack offers greater potential for a find (though setting up in the early morning hours is somewhat discouraging — especially for young observers).

But suppose your searching works and you detect a nebulous object unresolvable at high magnification, not shown in your star charts or mentioned in the IAU circulars. Make estimates of its position, magnitude and motion. The suspected comet's position can be read from and plotted on your star charts. You can determine its direction of motion by drawing a sketch of the immediate visual field and then checking its movement against the background stars after a half hour or so — but not much longer, or someone may beat you to the discovery. Make a magnitude estimate by locating a suitable comparison star of known brightness and then defocusing the image until it is the same apparent size as the possible comet. Comparing the "false comet" with the suspected one will yield a surprisingly accurate magnitude estimate.

When all this is accomplished, telegraph a report immediately to the Central Bureau for Astronomical Telegrams in Cambridge, Mass. Speed in filing your report is critical since only the first three reports to arrive will be credited with the discovery. But use discretion. Have your find verified by a reliable

Comet Kobayashi-Berger-Milon (1975h) was recently discovered by three astronomy enthusiasts as they searched the heavens. Though not a particularly spectacular comet, 1975h will be recorded in history by the names of the three observers who discovered it. This photograph of 1975h was taken through a 14 inch Schmidt camera on Tri-X film exposed for 15 minutes. The comet's tail was estimated to be five degrees long on Aug. 7. MacLean Observatory photograph.



Differences between comets and various types of nebulosity are not readily apparent except to the trained eye, as shown in this artist's comparison of a newly awakened comet and a distant galaxy. Only slight spiral structure betrays the galaxy. Comet seeking requires a trained eye to notice such small differences. Artwork by Victor Costanzo.

source — someone with knowledge of astronomy.

If you want a reasonable chance to discover a comet, you should expect to spend between 100 and 200 hours per year scanning the skies. The more active comet hunters spend 300 or more hours per year at this hobby.

Photographic Comets

No matter how long you stare at an object, its brightness remains the same. Eyes just can't integrate light over a period of time to yield a brilliant image. But film at the viewing end of a telescope can continuously record a faint light source over a period of time, building a brilliant photographic representation. The human eye simply can't compete with this advantage.

Photographic surveys of the sky made by professional and nonprofessional astronomers alike often capture comets on film. Since these "discovery" photographs are time exposures, the comets are recorded at faint magnitudes — considerably beyond the range of small telescopes. Today about 50 percent of all new comets are discovered photographically; most would have eventually been found by astronomy enthusiasts. Astrophotography has become an unexpected source of competition for the comet hunter.

With half of all new comets being found photographically, rivalry for discovering those remaining comets has peaked. It's difficult to estimate how many observers are engaged in comet hunting at any one time, but it numbers in the hundreds. The Hoshino Hiroba comet hunting society of Japan has nearly 200 active members.

Serious comet hunting is a definite test of endurance. Nights once spent at the telescope casually viewing the heavens are replaced by observing schedules. Although a demanding experience, it's an exciting one and it increases your observing skills. As you scan the skies for other objects be on the alert for comets. Leslie C. Peltier, a well-known comet hunter, has discovered 12 comets — six of them independent discoveries — and he doesn't even observe in the comet haystack! The observing skill — the training of the eye to recognize faint objects and discern detail — is a fine reward for the practice.

Recognition and notoriety that comes to a successful comet hunter sparks many hunters. Or perhaps the chance to see something no one has ever seen before — the excitement of search and the thrill of discovery — stimulates the seeker. Whatever the reason, comet hunting attracts the dedicated observer willing to spend long hours scanning the skies, seeking his own elusive comet.

Frank Apsi is a senior engineer and coordinator for Real-Time Computer Simulation with United Technology Corporation. He is an avid astronomy enthusiast, writes science fiction and has had several free lance articles published in fields other than astronomy. Apsi also assisted in establishing a comet hunting program in the Manchester, Conn. area.

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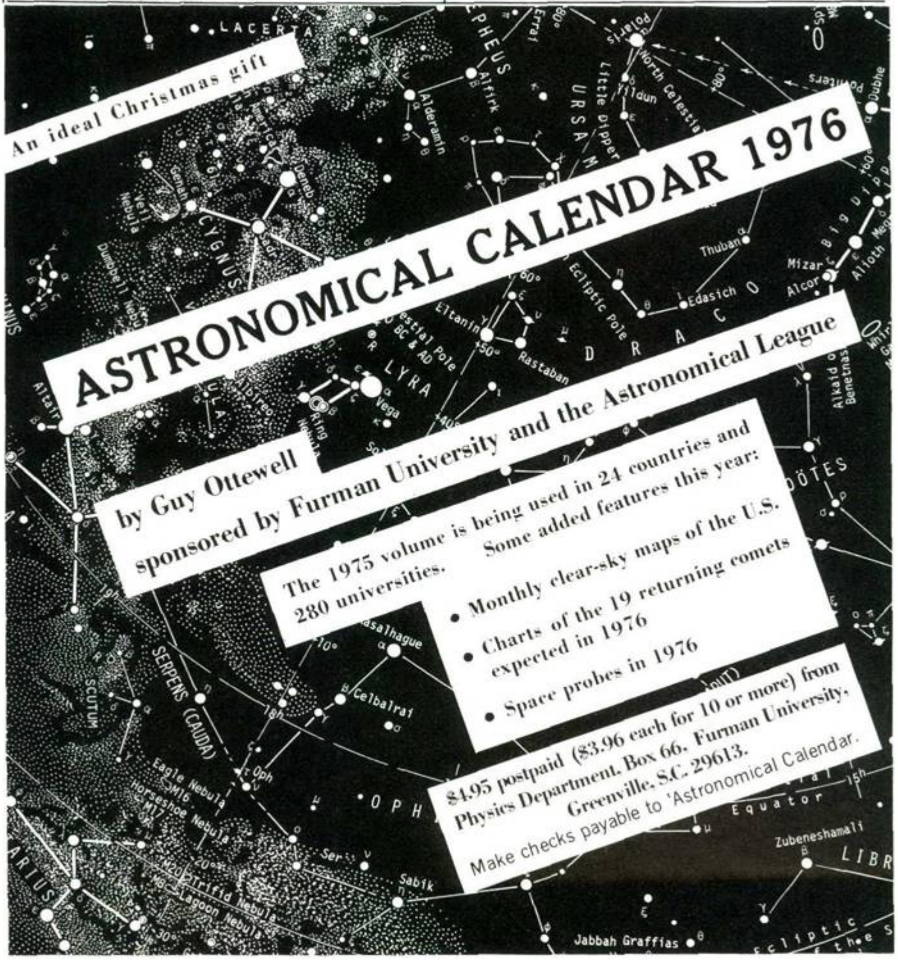
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continued on page 47

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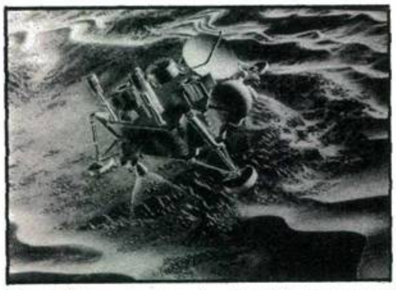

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SKY ALMANAC

Cygnus Had a Busy Summer

Several celestial events capture interest during November. A total eclipse of the moon, visible over most of the United States, occurs on the 18th of the month. The minor planet Ceres moves through the Hyades star cluster as it approaches opposition, and Jupiter continues to be an outstanding subject for viewing.

Mercury

Mercury is a morning star the first few days of the month, rising at 5 a.m. The planet reaches superior conjunction on the 28th, so reasonable Mercury observing will be limited to the first half of November. The small planet displays an 85 percent crescent on the first, and nearly full face by midmonth; its magnitude remains at a bright -0.8. On Nov. 8, Mercury will be one degree north of Uranus (magnitude +6.0), making an interesting binocular pair.

Venus

Venus, a brilliant morning star for all of November, rises about 2:45 a.m. at the beginning of the month and shortly after 3 a.m. by the end — approximately four hours before the sun. The planet displays half its face to us at the beginning of November and becomes a 60 percent illuminated disk by Nov.

Recorded with a 5.5 inch f/1.65 Schmidt camera on Fujichrome R-100, the North American and Pelican nebulae stand out brilliantly against the star clouds of Cygnus. The 25 minute exposure was taken at the Condor Observation Site on 8,000-foot Mount Pinos in *California*. An added attraction is the faint meteor trail cutting down through the North American nebula from the upper left. Photograph by Dennis Craig Stayer.

30. On the 7th, Venus reaches its greatest elongation west of the sun (47 degrees to the right, as seen from Earth). Its magnitude decreases from a "blinding" -4.1 to an only slightly dimmer -3.9 by Nov. 30.

Mars

In Gemini and rising around 8:30 p.m. on the 1st, Mars is well up in the sky by month's end — transiting the meridian at about 3:30 a.m. early in November, and 1 a.m. later in the month. The red planet begins *retrograde* motion (apparent backward motion along its path among the stars) on Nov. 6, and becomes increasingly bright (from -0.8 to -1.4 magnitude) as it approaches a Dec. 15 opposition.

Mars moves 10 million miles closer to us during November from a distance of 63 million miles at the beginning of the month. As it does so, its diameter increases from 14 to 16 seconds of arc. Next month will be excellent for observing the red planet.

Jupiter

Though past opposition, the largest of the planets is still well placed for observing. In Pisces, Jupiter is well up at sunset — transiting at approximately 10:30 p.m. early in November and 8:30 p.m. by month's end.

Earth is moving away from the giant planet. On the 1st, a distance of 373 million miles separates us; by the end of the month this has increased by 26 million miles. Jupiter's size decreases accordingly — from 49 to 46 seconds of arc equatorially and 46 to 43 seconds at the poles. The planet dims by only 1/10 magnitude during November, however. Jupiter shines at a dazzling -2.4 for the majority of the month.

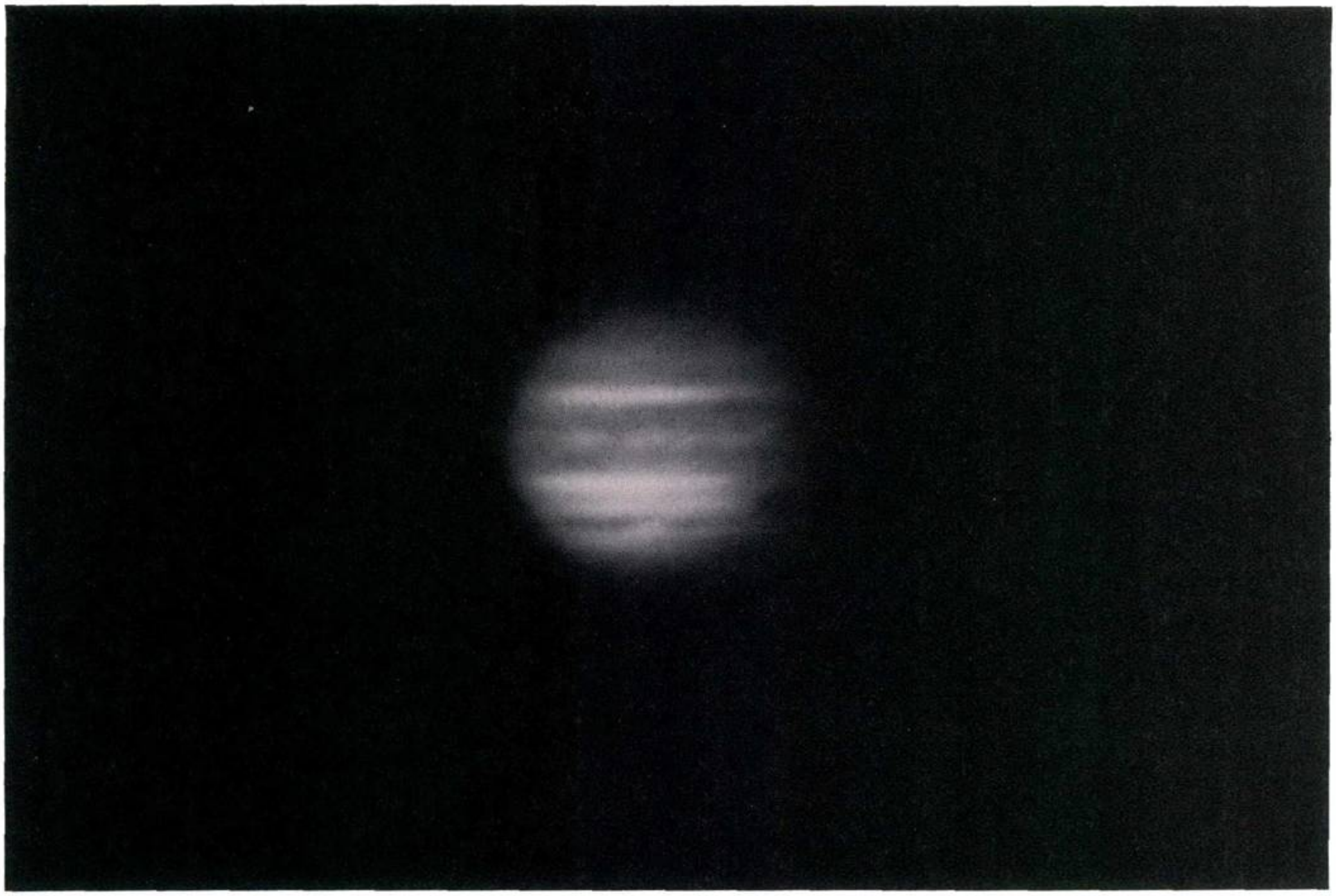
Saturn

As the month begins, the ringed world Saturn rises by 10:30 p.m.; when November draws to a close, it will rise by approximately 8:30 p.m. Located in Cancer, the planet will be stationary in right ascension on the 14th before it begins retrograde motion (as Mars does on Nov. 6).

Earth is drawing closer to Saturn from 829 million miles on the 1st to 787 million by the end of the month. As we approach, the planet gets

The Red Spot appears on the limb of Jupiter in this photo taken in August on high contrast copy film. A Nikon camera mounted on a home built eight inch telescope utilizing 7mm eyepiece projection recorded the planet in seven seconds. Photograph by James K. Rouse.

A red Perseid courses to its end, recorded on GAF 500 film exposed through a 28mm lens at f/3.5, offering a wide field of view. The piggyback exposure was guided on an eight inch, f/6 Cave Newtonian reflector. Photograph by George Shoup and B. Labadie.



Photograph by John Brandon

Gates Planetarium Photograph

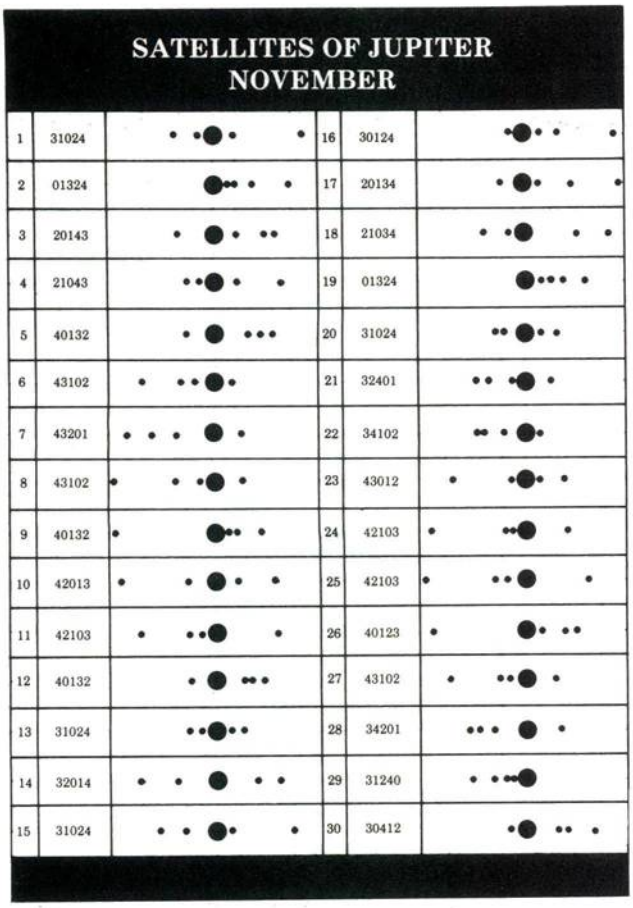
Photograph by James Kerr

brighter and larger — increasing in magnitude from +0.4 to +0.3, and in size from 19 to 19.6 seconds of arc equatorially and 17 to 17.5 seconds of arc at the poles. At 11 p.m. (EST) on the 24th, Saturn will appear four degrees north of the waning moon.

Ceres

During November, the minor planet Ceres moves westward through Taurus, approaching opposition on Dec. 1. The largest and first discovered of the asteroids will approach within 162 million miles of Earth when it reaches opposition. As the plot shows, this opposition will be particularly interesting — Ceres at magnitude +6.8 will be entering the Hyades star cluster. Ceres never gets above this magnitude, and must be viewed with a telescope or binoculars.

SATELLITES OF JUPITER NOVEMBER



1	31024	16	30124
2	01324	17	20134
3	20143	18	21034
4	21043	19	01324
5	40132	20	31024
6	43102	21	32401
7	43201	22	34102
8	43102	23	43012
9	40132	24	42103
10	42013	25	42103
11	42103	26	40123
12	40132	27	43102
13	31024	28	34201
14	32014	29	31240
15	31024	30	30412

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 7 p.m. (EST) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0= Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

Photograph by Marvin J. Mayo
and Michael O'Neil

Photograph by Brad Wallis

Photograph by Brad Wallis

Photograph by James Fanson

Photograph by Gordon Moeller and Gary Shook

Lunar Eclipse

A total lunar eclipse, visible over most of the U.S., will occur on Nov. 18. Since the eclipse begins at 5:03 p.m. (EST) in the afternoon, it will not be as spectacular as May's dramatically dark lunar eclipse. As the area of visibility chart on page 44 shows, the northeastern and southwestern U.S. will not be able to view it. The moon will enter the penumbra long before sunset (at 4:26 p.m. EST); totality will begin approximately 15 minutes after the sun slides below the horizon, ending about 1-1/2 hours after sunset. The moon will be located just five degrees southwest of the Pleiades, on the border between Taurus and Aries. The chart gives specific times for eclipse progression.

In addition to our regular report of planetary positions and upcoming celestial events, several recent stellar happenings have prompted the submission of many photographs and reports from our readers. Comet Kobayashi-Berger-Milon (1975h) proved a boon for astrophotographers. Three excellent photographs of the comet as it made its way southward were taken by California photographers (page 39). On July 29, 1975h was captured on 103aE film with a Pentax mounted at the prime focus of a 4.25 inch, f/5 home built reflector (far left). The

Photograph by Gordon Moeller and Gary Shook

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit Begins (EST)	Transit Ends (EST)
Nov. 1	1	4.07 a.m.	6.19 a.m.
2-3	1	10:36 p.m.	12:48 a.m.
4	1	5:05 p.m.	7:16 p.m.
7	2	12:46 a.m.	3:23 a.m.
10	1	12:31 a.m.	2:43 a.m.
11	1	7:00 p.m.	9:12 p.m.
14	2	3:23 a.m.	5:59 a.m.
17	1	2:27 a.m.	4:38 a.m.
	2	4:41 p.m.	7:17 p.m.
18	1	8:56 p.m.	11:07 p.m.
20	1	3:25 p.m.	5:36 p.m.
	3	4:15 p.m.	6:43 p.m.
24	2	7:18 p.m.	9:53 p.m.
25-26	1	10:52 p.m.	1:03 a.m.
27	1	5:20 p.m.	7:31 p.m.
	3	8:17 p.m.	10:44 p.m.

1=Io
2=Europa
3=Ganymede
4=Callisto

10 minute exposure was taken in the Malibu Mountains. The photographers estimated visual magnitude of the comet at 4.4, and determined that its tail extended four degrees across the sky. Two photos taken on Aug. 3 (center, page 39) and Aug. 10 (right, page 39) show the comet's further development as it moved toward a Sept. 5 perihelion passage. The center photo (taken on Aug. 3) is a 15 minute exposure taken on 103aF film, using a 135mm f/4 lens on a Minolta camera. The bright double star Alcor and Mizar appear above and to the right of 1975h as it moved through Ursa Major. Seven days later, the comet was again photographed near Thousand Oaks, Calif. with 103aO film in a Pentax camera mounted on a home built 4.25 inch f/5.6 reflector. M-106 appears in the upper right hand corner of the photograph, recorded by the 17 minute time exposure.

Another California photograph of Kobayashi-Berger-Milon comes from Redondo Beach (page 43). The comet was still in the constellation Cygnus when this picture was taken on July 21. Steve Reed mounted his Minolta camera piggyback style on an equatorial clock driven telescope for a 15 minute exposure. The comet, upper right in the picture, and rich star fields were captured on Fujichrome R-100 with the 58mm lens wide open at f/1.4.

Not all fine comet photos came from California, however. On Aug. 7, an Indiana astronomy enthusiast recorded 1975h on Anscochrome 500 (bottom, page 38). Using a Pentax ES mounted piggyback on a Criterion RV-6 Dynascope, the photographer made an 8 minute 30 second exposure through a 55mm f/1.8 lens. The entire Big Dipper was recorded, and the comet appears almost directly above the "nose" of the out-of-focus Dynascope. The exposure was hand guided while the comet was viewed at 180 power.

Observers across the country also enjoyed the Perseid meteor shower, which reached maximum on the night of Aug. 12-13. ASTRONOMY received numerous excellent reports, charts and photographs concerning the shower, and after reviewing the reports submitted, the following was determined:

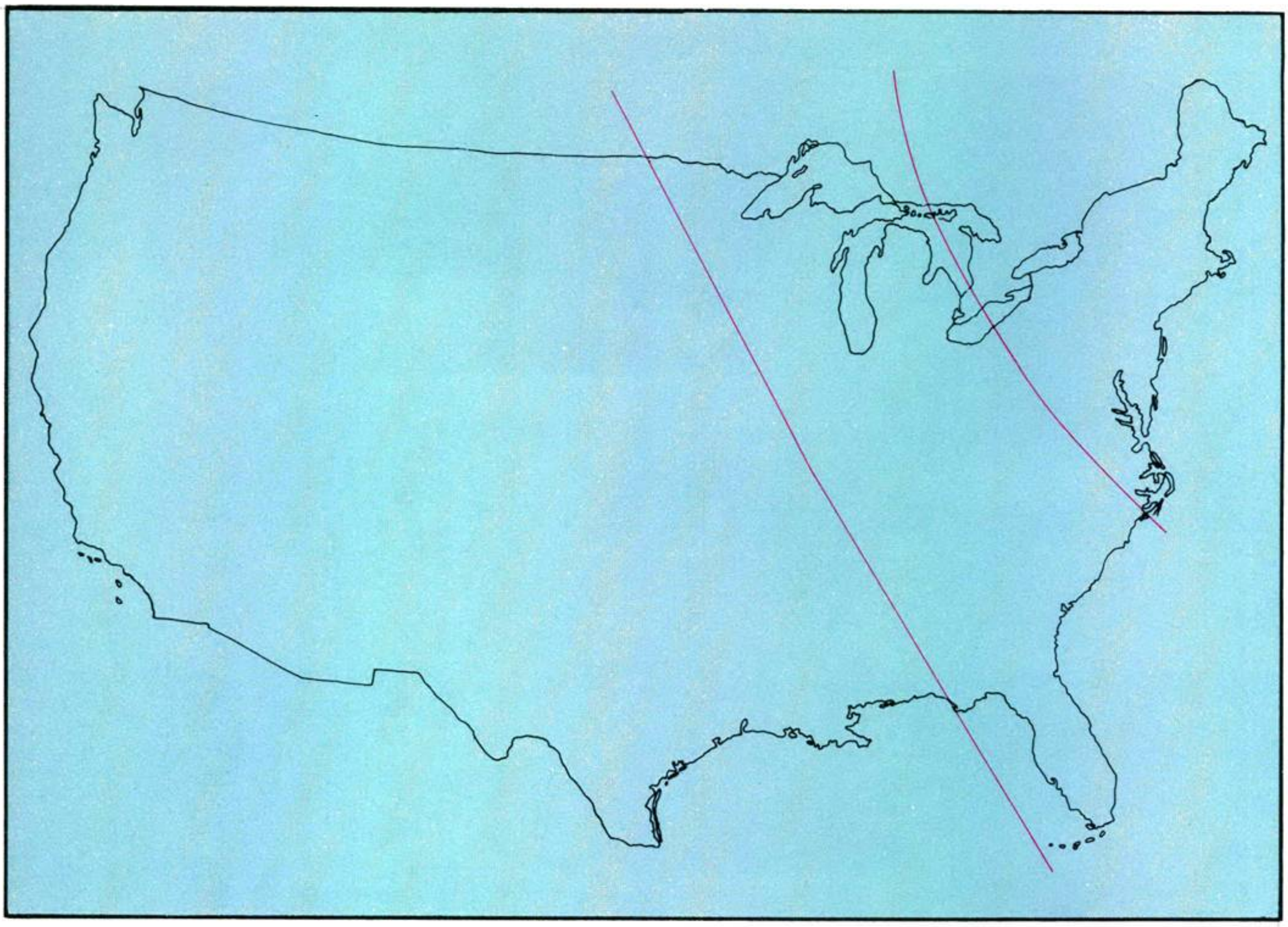
— Most observers saw an average of 35 meteors per hour — below the average of 50 that may be seen at the height of the Perseid shower.

— When all hourly totals were averaged, meteors on the night of Aug. 12-13 were visible every three minutes.

— A large number of bright meteors leaving trails were visible, but the trails were relatively short.

Photograph by Scott Wallace

Photograph by Steve Reed →



The total lunar eclipse of Nov. 18, 1975 will be visible only for viewers in the eastern United States. The line farthest east indicates where the moon will rise at the beginning of totality (the moon will rise above the horizon just as it enters the umbra of Earth's shadow). The line runs roughly east of Cleveland and west of Pittsburgh. The line farthest west indicates where the moon will rise roughly at the end of totality — through Winnipeg, Canada, Minneapolis, and Montgomery, Ala. Observers in the east will therefore have the best view of the eclipse, as they will see the moon higher above the horizon at midtotality. This eclipse is not particularly dark; the moon is passing south of the center of Earth's shadow. The plot was made with data supplied by Robert C. Elliott, University of Wisconsin Physics Department.

— The shower reached maximum between 3 and 4 a.m. (CST), and tapered off rather rapidly.

— Most meteors were estimated at between second and third magnitude.

— Perseid viewers submitting reports generally had excellent seeing (ratings varied from 8 to 9 on a scale of 10).

Proximity to the radiant point of the Perseid shower determined the length of the meteor trails left behind. Extremely short trails are evident when the meteor strikes Earth's atmosphere near the radiant. This is shown in the Perseid photograph on page 37. The photographer captured a rich star field with a five minute exposure on GAF 500, using a Pentax camera with a 55mm lens mounted piggyback on a home built six inch Newtonian reflector. The Double Cluster in Perseus appears in the upper left hand corner. Though the meteor appeared blue visually, the film recorded it as a vivid red in this exposure from the Hieroglyphic Mountains of Arizona.

Michigan also had clear skies for viewing the shower, as photographs on page 40 and 41 show. Both photographs were exposed on Tri-X film, obtaining rich star fields and long meteor trails. The Andromeda galaxy (M-31) appears vividly in the time exposure shot with a 55mm lens at f/1.4 on a Minolta camera (bottom, page 40). M-33 in Triangulum also appears as a small fuzzy patch in the lower left. Another meteor cut a trail through the area just over M-33 on the same night for the Michigan viewers (top, page 41), leaving a bright, long trail permanently recorded on film.

Star trails near Hercules are slashed by a bright Perseid in a photograph from Wisconsin (top, page 40). Tri-X pushed to ASA 1200 and exposed for 10 minutes in a Minolta SRT-102 mounted on a tripod recorded the image. Meteor trail astrophotography is easy with only the basics: A "normal" lens (50mm as in the Wisconsin photo, or 55mm) and an f-ratio of f/1.4, f/1.7 (used in the Wisconsin shot) or f/1.8 work well.

Some meteor trail photographers shoot their pictures with the lens "wide open" (the lens diaphragm open as far as it can be, allowing the maxi-

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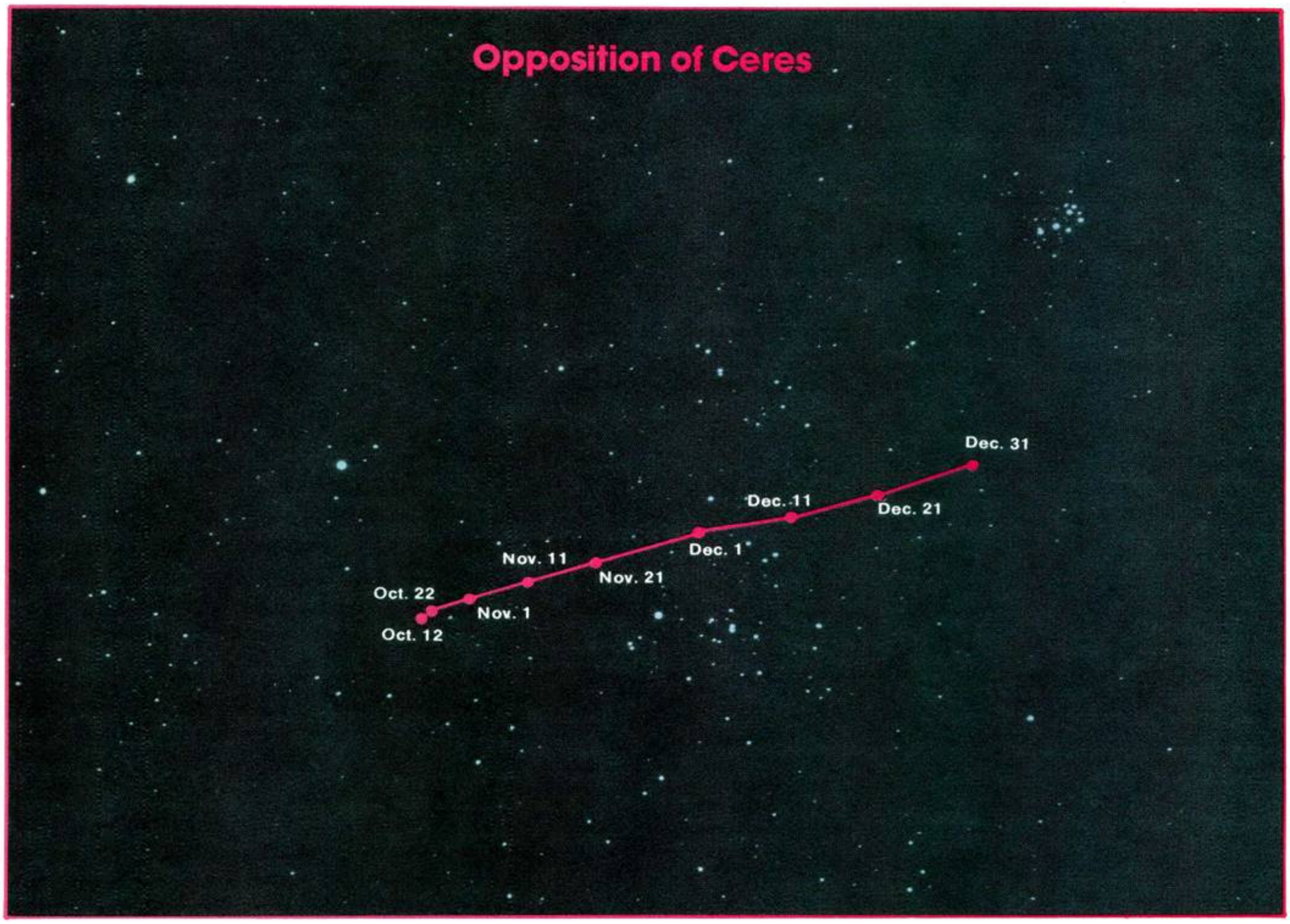

Ceres moves through the Hyades star cluster in Taurus during November and December, passing just below Epsilon Taurus by Dec. 1. The asteroid — a sixth magnitude object — moves quite rapidly during its approach to opposition. The map indicates its position at 10 day intervals.

mum amount of light to strike the film — the case in most of the photographs here), or they "stop down" the lens (shut the lens diaphragm a few stops) and increase exposure times to capture more light. Stopping down the lens eliminates the spreading of star images into tiny arcs toward the edges of the photograph. However, longer exposures on guided photographs are more tedious and sometimes produce as many problems as they attempt to eliminate — such as egg-shaped or spiked stars due to inaccurate guiding.

Another event in the constellation Cygnus captured attention in late August. Nova Cygni, born in the swan, was independently discovered and reported by numerous astronomy enthusiasts. First seen in the early morning of Aug. 29 by a Japanese observer, the nova blazed at its brightest on the 31st when it reached magnitude 1.87 and rivaled Deneb (magnitude 1.3) only five degrees away. On that day, it began to fade rapidly, slipping to second magnitude on Sept. 1 and fourth magnitude by Sept. 3.

Most reports indicated the object blazed blue-white at first, and became more yellowish in color as it grew progressively dimmer.

The nebulosity of the Cygnus region served as a vivid backdrop for the nova's burst of life. Stars of 14th magnitude were recorded in a five minute exposure on High Speed Ektachrome from the Gates Planetarium-Jefferson County Observatory (elevation 8,400 feet) in the Colorado Rockies (top, page 38). The nova blazed just left of and slightly above Deneb. The North American and Pelican nebulae form a small triangle with the two stars. The open cluster M-39 appears a short distance to the left of the nova, and a general pinkish cast from the hydrogen in the region is also evident. A Pentax Spotmatic II with an f/1.8 lens mounted piggyback on a 3.5 inch Questar recorded the nova and star field.

Tri-X film recorded the nova in 20 seconds in California skies through a Pentax camera equipped with an f/1.4 lens mounted on a tripod (bottom, page 42). The photographer processed his film in Microdol developer and printed it on grade 5 Ilford Ilfobrom paper. The nova appears in the center of the picture with Deneb slightly above and to the right. A distinct magnitude difference is shown between the two stars as their images were recorded on Aug. 29 — before the nova reached maximum brightness.

ASTRO-MART

continued from page 33

FOR SALE — Hanimex Praktica 35mm camera (lens and adapter for Japanese scope); $100.00. Korvettes XAM calculator; $55.00. Write Thomas L. Barth, 8106 Tahona Dr. - #222, Silver Spring, MD 20903.

FOR SALE — Sears 7 x 50 wide-angle binoculars; $35.00. Tasco 7 x 35 binoculars; $20.00. Both in excellent condition with cases; will sell both for $50.00. Contact Roger W. Gordon, 637 Jacobsburg Rd., Nazareth, PA 18064. Phone (215) 759-6805 after 5 p.m.

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WANTED — Correspondence from persons interested in science. Ages 13-15 preferred. Write Doug Vakoch, R.R. #2, Ada, MN 56510.

WANTED — October 1973 issue of ASTRONOMY. Must be in fair to good condition. Will pay up to $8.00. Please write Ross Gutow, 102 Hillview, Greenville, OH 45331.

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WANTED — Correspondence with young people interested in astronomy, astrology, UFOs, extraterrestrial communication and intelligences. Write Mark Vito, 4970 Virginia St., Gary, IN 46409.

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WANTED — Information on Orion region. Correspondence from persons in Miami Lakes area interested in forming astronomy club. Also interested in an astronomy pen pal in the 12-15 page bracket. Write Brad Fitzgerald, 6651 Cow Pen Rd., Apt. B-207, Miami Lakes, FL 33014.

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WANTED — Pen pal to discuss amateur astronomy and other natural sciences. Preferably in 16 to 19 age bracket. Write Steven Maesk, 39 Celeste St., Manchester, NH 03103.

WANTED — Amateur optical and radio astronomers to join NOAP (National Observers on Aerial Phenomena), a nationwide astronomy/meteorology/UFO research organization. If actively interested in any or all of the subjects, please write NOAP, 39 Edgewood Ave., Greenwich, CT 06830.

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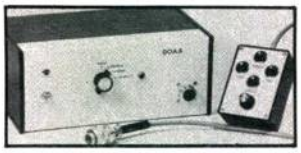

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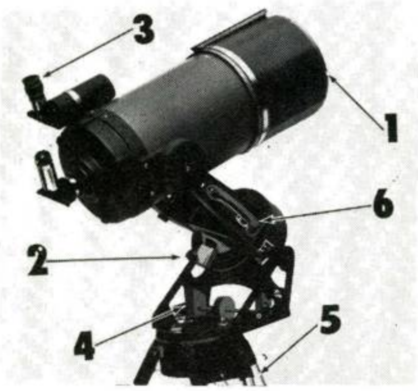

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WANTED — Equatorial refractor tripod with removable cradle for mounting 7" diameter Cassegrain tube. Prefer slow motion and polar drive. Must be reasonable. Write John Strong, 1400 Kentucky, Lawrence, KS 66044.

WANTED — Color photo of NGC-3242 (Jupiter's Ghost). Preferably taken in 4" (or less) scope. Film type and exposure time should be included. Write Rowen S. Poole, 49 Kendall Ave., Pittsburgh, PA 15202.

WANTED — Correspondence with persons interested in observing deep sky phenomena (Messier objects and NGCs). Contact Roy Kampfer, Forrest Central Dr., Titusville, NJ 08560. Phone (609) 737-1031.

WANTED — Celestron 14 or 14" Schmidt camera. Contact Carl T. Kantor, 2025 Cedarcrest Dr., Birmingham, AL 35214. Phone (205) 798-5520.

WANTED — Correspondence with persons interested in astronomy and/or science fiction. Ages 12-15 preferred. Write Carl Rossi, 644 S. Rosalind Dr., Orange, CA 92669.

WANTED — Back issues of ASTRONOMY: January, February, May, August, 1974. Will pay $3.00 each if in good condition. Write Ricardo Garcia, P.O. Box 585, Charlotte, TX 78011.

WANTED — Correspondence from owners of the new Cave Astrola f/5 supercompact 10" Newtonian. Write Skip Gilbert, P.O. Box 367, Oyster Bay, NY 11771.

WANTED — Correspondence from owners of Criterion Dynamax 8. Write Norman L. Happe, R.R. #1, Wadesville, IN 47638.

WANTED — Correspondence with persons interested in comparing philosophy and personality of "Star Trek's" Mr. Spock with John Galt and Lazarus Long. Send SASE for reply. Write Harold G. Wootan, 3737 Hillcroft - #178, Houston, TX 77027.

WANTED — "Lost in Space" gum trading cards. Please quote your price or send for my offer. Write Robert Cain, 1326 W. 6th Ave., Mesa, AZ 85202.

WANTED — Books in Rick Brant juvenile series by John Blaine: "Danger Below" and "The Deadly Dutchman". Needed to complete set. Will pay up to $10.00 each if in good condition. Contact John Holobosky, 2063 W. Romneya Dr., Anaheim, CA 92801. Phone (714) 772-3078.

INFORMATION WANTED — On variable frequency clock drives; any plans or literature are welcome. Also want books on radio astronomy. Write Richard Hoffman, 93 Winter St., Bronx, NY 10464.

INFORMATION WANTED — On procedures and accuracy of E. Gaviola's test for Cassegrain secondaries. Write Wayne Jones, W. 4706 Deska Dr., Spokane, WA 99204.

INFORMATION WANTED — On catalogs, books, etc. on astronomy or telescopes. Also names and prices of science fiction magazines. Write Norman Kolb, R.R. #1; Benson, IL 61516.

INFORMATION WANTED — On astronomy clubs in Brooklyn or Queens (general metropolitan area). Write John C. May, 2630 Cropsey Ave., Apt. 6A, Brooklyn, NY 11214.

INFORMATION WANTED — Small group of serious amateurs is seeking good observing sites within 80 miles of Detroit. Contact Larry Sauvain, 16765 Rudgate, Southgate, MI 48195. Phone (313) 287-4294.

INFORMATION WANTED — Name of manufacturer or plans for building 10' to 12' diameter rotating dome (of aluminum) which can be erected on concrete slab to permanently house 12-1/2" Cave Newtonian reflector. Contact Michael Clark, R.D. #3, Nazareth, PA 18064. Phone (215) 759-6873.

INFORMATION WANTED — Plans or blueprints for construction of observatory for a Celestron 14 and Monolux 2.4" refractor. Write Bruce Abbott, Box 984, Westhampton Beach, NY 11978.

INFORMATION WANTED — On astronomy (books, magazines, etc.). Send to North Kingstown High School Astronomy Club, 107 Chatsworth Rd., North Kingstown, RI 02852.

INFORMATION WANTED — On high school observatories and how to build a radio telescope. Write Edward Lichtenfels, 326 McMahon Dr., North Huntingdon, PA 15642.

INFORMATION WANTED — On location of motels within 50 miles of New York City in areas well suited/situated for astrophotography. Motels rates should be reasonable; prefer southeastern panorama. Write Bill Siletti, 22-32 Steinway St., Astoria, NY 11105.

INFORMATION WANTED — Correspondence from owners of Polaroid ED-10 on its use as an astrocamera. Please include information on mounting, exposure times, etc. Write Larry Peters, 600 Harborview Rd., Pittsburgh, PA 15239.

INFORMATION WANTED — On obtaining a plastic model of the Skylab Space Station and/or ASTP (if available). Write Julius Pangilinan, 1861 Palmetto St., Ridgewood, NY 11227.

ASTRONOMY
Guide to Back Issues

Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. The following back issues are depleted: September, October, November, December 1973; January, February, August, December 1974; and April 1975.

Below is a guide to ASTRONOMY back issues that are still available. For your convenience it is updated monthly, and completely revised about every six months. While they last, back issues are available for the cover price of $1.50 each (price includes postage).

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

Vol. 1, No. 1 - August 1973	Available	Vol. 3, No. 7 - July 1975	Available
Vol. 2, No. 3 - March 1974	Available	Vol. 3, No. 8 - August 1975	Available
Vol. 2, No. 4 - April 1974	Short Supply	Vol. 3, No. 9 - September 1975	Available
Vol. 2, No. 5 - May 1974	Short Supply	Vol. 3, No. 10 - October 1975	Available
Vol. 2, No. 6 - June 1974	Short Supply	Vol. 3, No. 11 - November 1975	Available
Vol. 2, No. 7 - July 1974	Available	Vol. 3, No. 12 - December 1975	*NYP
Vol. 2, No. 9 - September 1974	Available	Vol. 4, No. 1 - January 1976	*NYP
Vol. 2, No. 10 - October 1974	Available	Vol. 4, No. 2 - February 1976	*NYP
Vol. 2, No. 11 - November 1974	Available	Vol. 4, No. 3 - March 1976	*NYP
Vol. 3, No. 1 - January 1975	Available	Vol. 4, No. 4 - April 1976	*NYP
Vol. 3, No. 2 - February 1975	Short Supply	Vol. 4, No. 5 - May 1976	*NYP
Vol. 3, No. 3 - March 1975	Short Supply	Vol. 4, No. 6 - June 1976	*NYP
Vol. 3, No. 5 - May 1975	Available	Vol. 4, No. 7 - July 1976	*NYP
Vol. 3, No. 6 - June 1975	Available		

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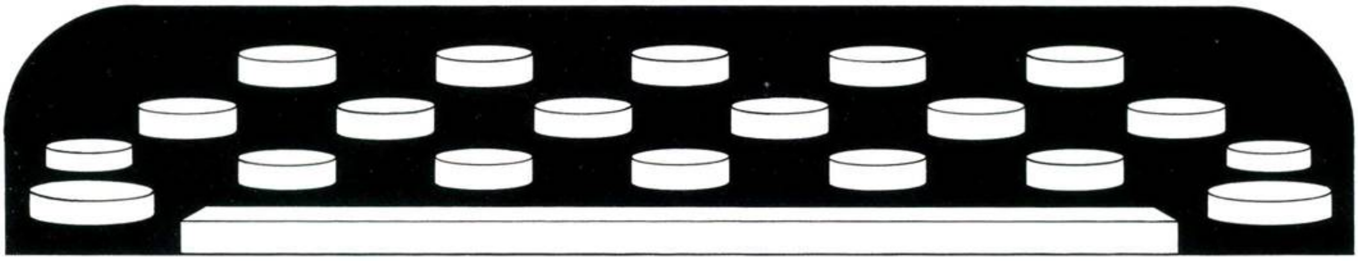

IN FOCUS

EDITOR'S NOTE: The sunspot photograph on page 47 of ASTRONOMY, September 1975, was incorrectly designated a Solar Research photograph. The photo was from Carson Astronomical Instruments. The solar flare photograph on page 33 of the October 1975 issue was incorrectly attributed to Leo C. Henzl Jr. The photo was taken by Edwin Hirsch.

Sir / I've enjoyed your magazine for the last 18 months. The articles are generally well written and excellently illustrated. However, I believe an error exists in the September 1975 issue. The top of page 72 reads, "The entire spiral rotates, with our solar system completing one trip around the center in 200 million years." Then in the Astro-News article "Long Term Forecast Given" (on page 57 of the same issue) it says, "The period between ice epochs is just half the time it takes the solar system to make one orbit around the Milky Way galaxy (about 500 million years)." Both of these statements can't be right. This small error is probably only a simple misprint; I would appreciate it if you would clear this up.

ROBERT BURTON
Wheeling, Ill.

Mr. Burton / The 500 million year figure in the Astro-News article prompted several letters from our readers asking which number — 500 or 200 million years — was correct. The 500 million years was indeed a typographical error. Most authorities agree the solar system orbits the galaxy once every 200 to 250 million years.

Sir / The letter by Philip Klass (June 1975) reminds me of the entry in Project Blue Book in which an unidentified object was tentatively identified as "a bird with four lights". Klass "suggests the *possibility*" that the unidentified object reported by Robert Purdy (December 1974) — which at first seemed to be a satellite until it "abruptly stopped and reversed its motion" in the vicinity of Alderamin (Alpha Cephei) — may have been a Russian Molniya communications satellite whose unusual orbit results in such a ground track.

It is quite simple to calculate with numbers provided by Klass and with the assumption that the satellite radiates as a sphere 30 feet in diameter with an intensity equal to that of solar

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radiation at Earth's atmosphere (that is, the surface intensity is approximately 0.14 watts/cm^2) — that the apparent magnitude of the satellite at a distance of 25,000 miles is 9.3, and would not be visible to the unaided eye. The limiting magnitude for the dark-adapted eye is 6.2 (according to Thornton Page and Low Williams Page in **Telescopes**).

Another estimate of the visual magnitude of the Molniya satellite can be made from the rule-of-thumb adopted by Pilkington ("The Visual Appearance of Artificial Satellites" in **Planetary Space Science**, Vol. 14), in which it is assumed for Soviet spacecraft that a one meter sphere at 1000km slant range appears as magnitude +7.84. From this criterion the visual magnitude of the Molniya satellite at 25,000 miles altitude is about 10.9, again indicating invisibility to the unaided eye.

The map accompanying Klass's letter shows the position of the satellite as a function of time by hour marks placed on the ground track. Hour marks on the track in the vicinity of the "reversal" over Hudson Bay, at which time the satellite is approximately at 25,000 miles altitude, indicate that it takes an hour to traverse about 0.5 degrees over the sky (as seen from the ground) as the satellite approaches its apogee; another hour to traverse through about 0.4 degrees while going through its "reversal", and another hour to move through about one degree in its motion away from apogee. In other words, the satellite, if visible, would appear to be almost stationary to an observer on the ground throughout a period of three hours preceding, during and following its "reversal". No observer would say that the satellite "abruptly stopped and reversed its motion".

It should be obvious from these two considerations that the object which Purdy described was definitely not a Russian Molniya communications satellite.

CARSTEN M. HAALAND
Oak Ridge National Laboratory
Oak Ridge, Tenn.

Sir / On page 11 of the September 1975 issue, there is a painting by Adolf Schaller of an asteroid impact on the early Earth. The caption on the bottom right of page 10 reads in part, "Fortunately the only life on Earth consisted of single-celled ocean life."

Why are the islands in this picture shaded green?

MIKE SLOBODA
Ferguson, Mo.

Mr. Sloboda / The areas shaded green in the artwork by Schaller were not intended to be islands — they are shallow areas beneath the continental seas on Earth two billion years ago. Part of the intensity of the green is caused by the printing reproduction of the original artwork. Additionally, James Oberg (author of "Baptism of Fire") emphasized that after the impact only single-celled life remained. Before the collision, no one knows what life existed. Great evolutionary changes and setbacks could have been caused by such an event.

Sir / I enjoyed your article in the December 1974 issue ("The Zeta Reticuli Incident") and "The Age of Nearby Stars" in the July 1975 issue. Both were excellently written, but I noticed the following technicalities:

1) In July 1975 (page 24), you show a

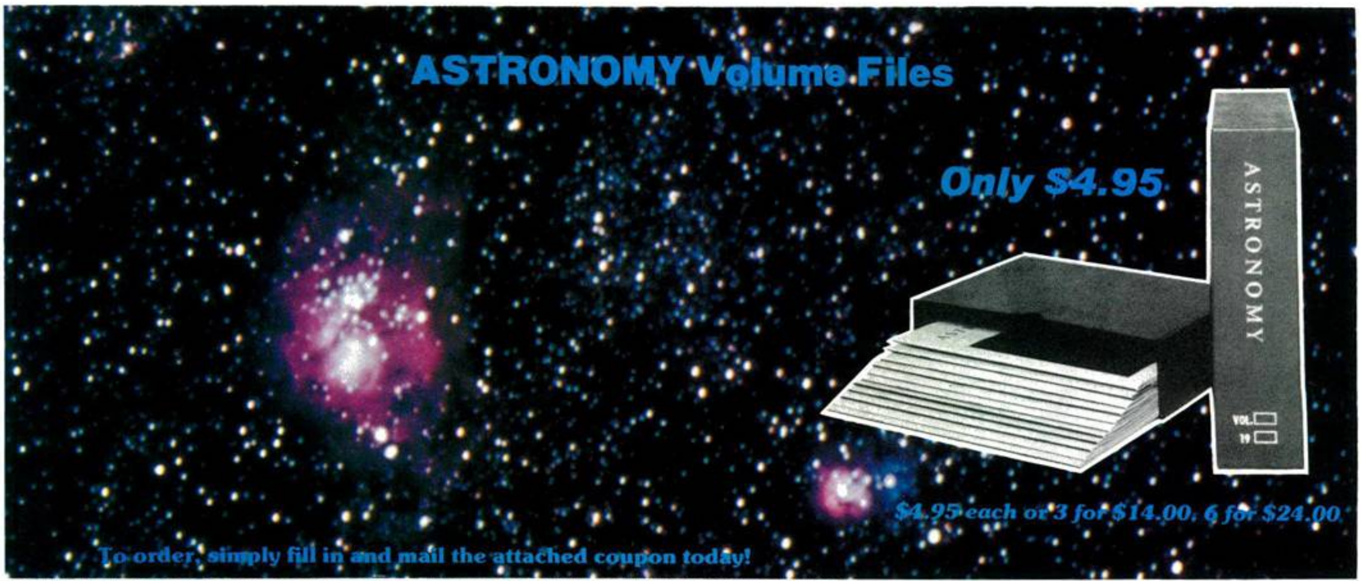
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chart with the characteristics of the Fish-Hill pattern stars. This chart lists Zeta 2 Reticuli as a G1 type star. On page 17, however, in the December 1974 issue, on the chart of the 46 stars that are within 55 light-years of the sun (and also similar to it), you list Zeta 1 Reticuli as a G2 type star.

2) Also on the chart on page 24 of the July 1975 issue, you list the sun as a G5 star. But in the text (on page 9 of the December 1974 issue), you twice state that the sun is a G2 type star.

I would greatly appreciate your setting me straight on these two facts. I realize they are small, but nevertheless important.

MATTHEW LAUDATO
Northport, N.Y.

Mr. Laudato / Thank you for your scrutiny. In response to your first point, Zeta 1 Reticuli is indeed a G1 star – not a G2. (According to the Yale University Observatory **Catalogue of Bright Stars**, *it is a G1V, to be exact.) A little research revealed a typographical error in the December 1974 issue. Another typographical error accounts for our sun being "lowered" to the G5 classification. Our star is, in response to your second point, a G2 type star. We will try to eliminate printing errors such as these in the future.*

Sir / I noticed an error in ASTRONOMY, August 1975, page 8. In the illustration depicted on that page, you list Earth's orbital velocity as 22.5 miles per second; the correct velocity is 18.5 miles per second. Since that is the stream velocity in the diagram, I assume you have these two velocities switched around. I am sure that most readers caught the error, but someone unfamiliar in this area might be misled. Below the diagram, however, you list Earth's orbital velocity as 66,000 m.p.h., which is correct and equal to 3,600 seconds per hour times 18.5 minutes per second.

ROGER BREZINA
Mankato, Minn.

Mr. Brezina / We stand corrected.

Sir / On July 2, 1975, the waning crescent moon was just north of Jupiter. I had intended to photograph the moon - Jupiter - Mars configuration before dawn but clouds prevented me from doing so. However, at 9:30 a.m. when the sun was well up, I was favored with clear skies. I readily spotted Jupiter with binoculars and set up my Celestron 5, using 50 power. I was rewarded with one of the best views I have yet had of the planet. The daytime sky greatly reduced the glare from the planet, resulting in a very sharp image. At 100 power I was able to detect many shaded variations in the bands – subtle variations I have rarely seen during nighttime viewing. However, I was unable to detect any of the satellites. I had previously observed Jupiter by daylight, especially at the time of its close conjunction with Venus last Feb. 17, but at that time was unable to make out any surface features.

FR. LUCIAN J. KEMBLE
Lumsden, Saskatchewan, Canada

Letters intended for this column should be addressed to The Editors of ASTRONOMY. We are sorry but the volume of mail does not permit individual replies.

ASTRONOMY: BLACK HOLES TO QUASARS

Produced only after extensive consultation with noted astronomers, this is the first comprehensive and complete coverage of astronomy specifically intended for those who want to enjoy the best in color astrophotography from the major observatories of the world combined with up-to-the-minute data on every phase of astronomy, presented in an easy-to-understand way. This set has it all, including the sun, moon, planets, asteroids, comets, meteors, stars, star clusters, Milky Way, nebulae, galaxies, galaxy clusters, black holes, quasars, etc. Enjoy the optional tape cassette recording which contains the detailed narration along with relaxing classical mood music and is keyed to the 40 color slides. Printed slide descriptions are also provided for those who do not intend to order the tape cassette recording. All slides are 35 mm in 2"x 2" mounts. The entire package is attractively gift boxed in plastic. USA orders send $.75 extra for postage. All foreign orders 20% extra.

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Cave Optical Co., Meade Instruments, Criterion Manufacturing Co., Unitron Scientific, Questar Corp., Edmund Scientific, S & S Optika, Superior Optics, Star-Liner Co., etc., etc., etc....

You probably recognize these names because they advertise in ASTRONOMY. They sell telescopes, and we know you buy their telescopes because they continue to advertise in the magazine. We also know from last year's readership study that 62 percent of ASTRONOMY's audience consider themselves photography enthusiasts. Even without the survey our daily inundation of excellent photos from you provide some clue to the strong majority photography enthusiasts hold.

Relating these various bits of information we must conclude, therefore, that many ASTRONOMY readers must use the above mentioned advertisers' equipment for astrophotography. Curiously absent from the equipment information on photos you supply us, however, are the names "Cave" preceding 8" f/7 Newtonian, or "Meade" preceding 3" refractor, etc. Perhaps stranger still is your enigmatic avoidance of the word "Questar" preceding 3-1/2" Cassegrain.

The coup de grace of late however, responsible for more than just a touch of editorial perplexity, is your unfailing consistency in telling "all" when your photographs are taken through the red/orange Schmidt-Cassegrain telescope!

What prompts this discussion? Recent reader reaction to photographs and articles in ASTRONOMY typified by comments expressed in a letter from Chris Little, Wichita, Kansas: "...you appear to have a fixation about Celestron telescopes and accessories. These particular Celestron items are constantly talked about, praised and given free advertising in almost every issue. In addition to this there appears to be a priority given to publish pictures taken with Celestron equipment over other types. I can only conclude that you have some sort of business relationship with Celestron and if this is correct I believe that a public announcement of that connection is in order. I feel like this because there must be many novice astronomers who think Celestron is the only way to go and are thus directed into a bigger investment than is warranted by their knowledge or experience."

We at ASTRONOMY have become extremely sensitive to these kinds of comments from readers and advertisers. And upon reviewing in depth both article and photo caption content from ASTRONOMY's September 1974 through August 1975 issues, it became uncomfortably apparent that readers could indeed get the erroneous impression that ASTRONOMY was a "classy" house organ for Celestron Pacific.

Publicly, for all concerned, Celestron is an advertiser in ASTRONOMY only! Other than this, there is no legal or other business connection or relationship between ASTRONOMY magazine or its parent AstroMedia Corp. and Celestron Pacific.

To rectify this effective with the September 1975 issue we started "chasing down" photo contributors to glean the absent equipment brand information. You can imagine what our phone bill was like that month. Therefore, effective immediately, photographs — no matter how excellent — will not be accepted for publication unless accompanying information includes the telescope manufacturer's name.

Cave, Meade, Criterion, Unitron, Questar, Edmund, S & S Optika, Superior Optics, Star-Liner, Celestron — all supply or manufacture good telescopes. And because of this, these companies deserve equal credit for their handiwork. By supplying the information we need to do a complete reporting job you will instrumentally contribute to fair, balanced editorial treatment for all, and help us give you the magazine you want. As we've said all along, you are what ASTRONOMY magazine is. The World's Most Beautiful Astronomy Magazine exists because you allow it to exist to serve you.

Moving on to brighter topics: ASTRONOMY now has 50,000 subscribers. Because we've been around for a bit more than two years, we process up to 10,000 subscription renewals during the course of any given month. On occasion, when we have lots to do, we work late at the office — like till 11 p.m. (you'd be amazed how much you can get done when nobody else is around). Recently during a laborious "graveyard" session I received one of those inevitable late-night calls from a subscriber. Frantically he explained that he was entering the army the next day, and would I check to be sure ASTRONOMY had received his renewal payment. I told him that the office staff who handles this sort of thing wouldn't be in the office until 8:30 a.m. and couldn't someone call him in the morning.

Innocently he inquired, "Well, don't you have it right there in front of you?"

"What do you mean 'right in front of me'?" I had to ask.

"I mean, isn't my renewal in the pile on the corner of your desk?"

We will start mailing orders for ASTRONOMY 1976 Sky Almanac (advertised on page 45 of this issue) during the first week of November which should pretty well guarantee delivery before Christmas. If you plan to give the calendar as a gift, however, we can't promise before-Christmas delivery on orders received after December 5.

ASTRONOMY's new calendar concept should allow us an economical way to offer readers framable reprints of the best art and photographs used in the magazine. If you have a particularly favorite painting or photo you'd like to see reprinted in the 1977 calendar, let us know and we'll see what we can do.

ASTRONOMY is looking for contributing editors to write Photography in Astronomy. Leo Henzl who has done so excellent a job for the past many moons will not be able to continue regular contributing editorship of the department due to pressing professional duties. If you would like to be considered as a contributing editor for Photography in Astronomy, let us know. Naturally, you should be a proficient astrophotographer, and have knowledge and experience with equipment, film, lenses, darkroom chemistry, techniques. It would help if you can write — but our editors will rewrite as long as your ideas are strong.

Would you believe? I've got lots more to talk about and have run out of room. Guess I'm getting loquacious in my old age. Talk to you next month.

Sincerely,

Stephen A. Walther

Stephen A. Walther
Publisher

ASTRO-NEWS

Latest News From the World of Astronomy

Sun to Help Energy Needs

The newest major energy agency has outlined a three part strategy to have the sun meet 1/4 of our nation's energy needs in 45 years.

The Energy Research and Development Administration described its national partnership with industry in a research and development effort to get widespread practical uses of the sun for heating and cooling buildings, creating electricity and turning farm wastes into energy.

By the year 2020, solar energy should be able to replace the equivalent of more than four million barrels of oil a day. That could represent 1/4 the nation's energy use by then.

The sun offers a huge and virtually inexhaustible potential supply of energy that is widely available over the United States. However, solar energy will not be utilized unless its costs — and in some cases environmental impact — can be reduced.

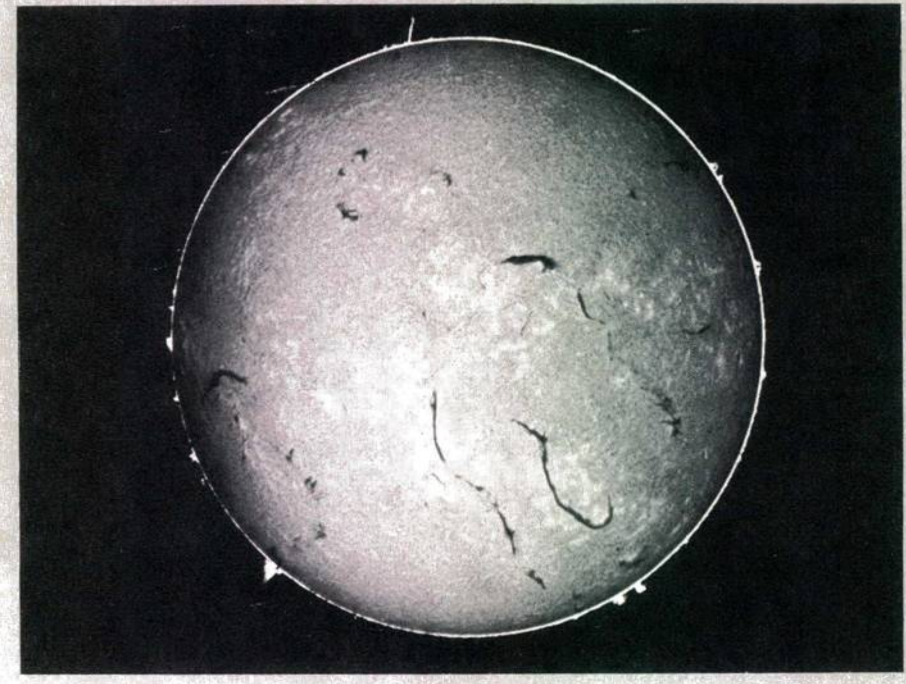
The effort's three directions are:

— Development of direct thermal applications, such as solar heating and cooling of buildings and use of solar heat for farming and industry processes. This is the most promising near-term application.

— Converting the sun's rays into electricity. This has a high priority for the future.

— Turning farm wastes and wood chips from logging into useful fuel gases such as methane, methanol and hydrogen. It will be the next century before these make a big contribution.

The energy agency has allocated $89 million for solar energy work in the current fiscal year, compared with about $1 million just four years ago.



High Altitude Observatory (Boulder, Colo.) photograph

Computer Aids Astronomers' Observations

In a trick done with mirrors and a computer, scientists say they have found a way to greatly reduce the atmospheric distortion that has plagued astronomers for centuries.

The new optical system for telescopes, developed by the Itek Corp., corrects distorted light from objects in space and instantly gives a clearer image.

Turbulence in Earth's atmosphere bends incoming light waves, blurring the images of stars and causing them to twinkle.

"Our system should make an enormous difference in the images received by large telescopes," according to John Hardy, project manager at Itek's Optical Systems Division.

The Itek system has been tested in the laboratory but not yet at an observatory. The company is making a prototype to be tested on a working telescope by the end of the year.

"It could improve the resolution by a factor of 10 or 20 or more," Hardy said.

The Itek system uses a device called a shearing interferometer and detector to measure the amount of distortion in the light entering a lens. A computer then gives continuous calculations on the amount of correction needed in the light to cancel out distortion.

A special mirror that changes its shape slightly when electric charges are applied corrects the light before the viewer sees it, the researchers said.

The Itek scientists say they believe their system has proved itself and is the most advanced of several solutions to distortion proposed by the researchers in their field. Most other proposed solutions have used up more light than they have saved.

Soviet Space Program to Introduce New Research Over 5 Year Program

The successful conclusion of the Soviet Union's Salyut-4 space station flight in late July 1975 has cleared the way for an active and ambitious Russian space program during the next five years. While Soviet cosmonauts will be flying into space on a regular basis, American astronauts will be grounded until the first space tests of the new Space Shuttle vehicle begin in 1979.

Salyut-4 was actually the sixth or seventh attempt to fly a space station mission. The first Salyut went into space in 1971, but the first crew could not dock with it and the second perished while returning to Earth. Later Salyut satellites failed in 1972 and 1973. The Salyut-3 station flew a military reconnaissance mission in 1974 with two cosmonauts spending 16 days in space, but little scientific research was carried out.

The Salyut-4 mission, however, carried an impressive array of research tasks — including space medicine, Earth resources, space engineering and astronomy. The experimental equipment on board the 20 ton space laboratory weighed more than 4,000 pounds.

Astrophysical instruments included the "OST-1" solar telescope, a set of solar spectrometers, an infrared telescope/spectrometer, two x-ray telescopes, and a cosmic ray spectrometer. Other Salyut space stations have carried the "Orion" UV (ultraviolet) telescope, but that equipment was not included in this mission.

The first space crew was sent into orbit in early January 1975, a few weeks after the space laboratory was launched. Two cosmonauts spent 30 days in orbit and completed a nominal mission.

The second crew was launched on a planned 60 day flight early in April. The cosmonauts were space veterans who had flown together the previous year. However, due to a booster failure, their Soyuz spaceship did not go into orbit and the crewmen made an emergency landing in Siberia.

Despite this unprecedented space failure, Soviet space planners went ahead with alternate plans. Six weeks later, after carefully studying the causes of the rocket failure, the USSR launched a third space crew into orbit. The planned Salyut mission was completed during a 63 day flight which had been extended a few days to overlap the Apollo/Soyuz (joint American-Soviet) space mission. Following their return to Earth, the Salyut laboratory was kept in orbit for possible further tests.

Soviet space officials have been carrying out an interesting series of experiments dealing with life support systems for long duration manned space voyages. Academician Boris Petrov said during the Salyut-4 mission that man's penetration into space had to await the development of systems being tested on Salyut-4. Now that these systems have been proven, the USSR can move ahead with plans to put cosmonauts into lunar orbit in modified Salyut space stations. Lunar landings are not planned for the near future.

More Salyut laboratories will be launched into Earth orbit shortly. The Soviets plan to carry out four to six manned missions a year for the rest of the decade, and by 1978 should be able to keep crews on improved space stations for more than a year through the use of supply flights and crew rotation. These orbital stations will be used for scientific research, military reconnaissance, and engineering development.

The flight of Salyut-4 marks an important new stage in Russia's space efforts, which had been lagging behind the United States for the last 10 years. This success is seen by many as demonstrating new levels of technological competence, scientific experimentation, and mission control confidence. Follow-on space missions will carry out new research programs over the next few months.

Heaviest Space Molecule Found by Radio Telescope

Although sulfur dioxide has only three atoms, it is the heaviest molecule so far discovered by radio astronomers in the dust clouds of interstellar space.

Sulphur dioxide appears in two celestial locations — the Orion nebula and the cloud called Sagittarius B2. Features of the profile of the sulfur dioxide emission from the Orion nebula indicate a two-component structure for the substance there — a dense envelope probably surrounding a star, and a warm galactic cloud component.

The observations were done with the NRAO 36 foot antenna at Green Bank, W.V.

Oxygen Isotope Aids Solar System Study

From variations in the nature of oxygen found in Earth, the moon and a wide range of meteorites, scientists at the University of Chicago have concluded these objects were not, as long assumed, formed from the same mix of primordial elements.

Rather, the scientists reported recently, it appears material foreign to the solar system penetrated parts of it early in the development of the sun and planets, and became incorporated more extensively into some objects than others.

This invading material was strongly enriched in one isotope or variant of oxygen, known as oxygen 16. It can therefore be used as a tracer to reconstruct the histories of the various solar system components.

The discovery is being hailed by some planetary astronomers as the most important development in their field in several years.

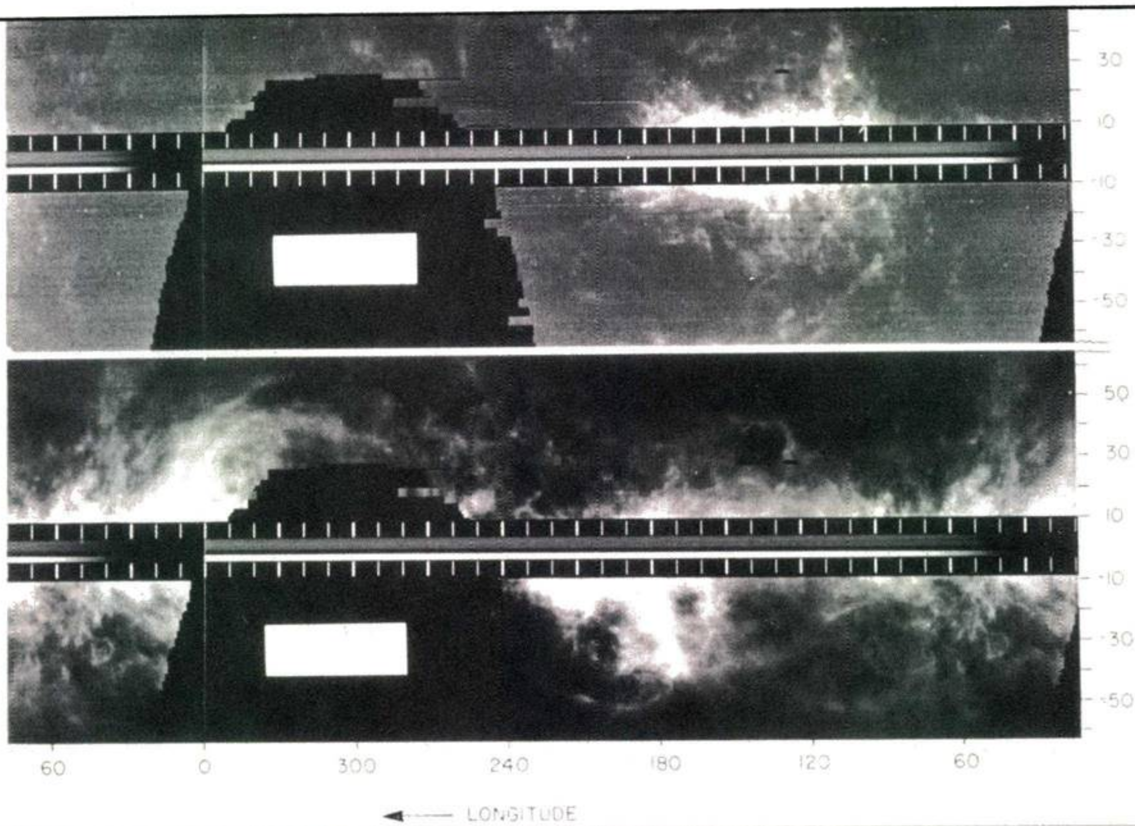
It has already been shown, for example, that Earth, the moon and certain meteorites stand in a class by themselves among those celestial objects so far sampled.

The remaining meteorite samples fall into four other classes implying formation in different regions of the nebula, or whirling cloud of material from which the sun, planets, moons and meteorites of the solar system were formed.

Five separate categories of "raw material" have so far been identified, representing five different admixtures of the alien oxygen with that native to the solar system. So far, the only massive body of the solar system to be sampled — apart from Earth — is the moon.

It is considered likely that at least those planets most closely resembling Earth — Mars, Venus and Mercury — will fall into the same category. That, however, will not be known until samples of their material have been retrieved.

Hydrogen Gas Distribution Shown



This remarkable photograph shows the distribution of nearby hydrogen gas in the sky. This gas can only be observed with a radio telescope; a computer was used to generate a photograph of what the radio telescope "saw". The map has galactic latitude and longitude coordinates, centering the Milky Way at latitude zero. The survey on which the map was based did not include the hydrogen clouds within 10 degrees of the galactic plane. Photograph reproduced with permission of Carl Heiles, University of California-Berkeley, and Edward Jenkins, Princeton University.

Nearest Satellite Galaxy Found

The nearest known external satellite galaxy, lying about 100,000 light-years from the center of the Milky Way and only about 70,000 light-years from the sun, has been discovered at radio wavelengths by S. Christian Simonson of the University of Maryland. The Magellanic Clouds, previously thought to be the nearest galaxies to the Milky Way, are more than 150,000 light-years distant.

The new galaxy is small, probably only about 1/1000 as massive as the Milky Way. It is the first member of the Local Group of galaxies to be discovered at radio wavelengths.

This brings the number of known members of the Local Group to 21. The last members to be discovered were three small satellites of the Great Galaxy in Andromeda, found in 1972 by University of Toronto astronomer Sidney van den Bergh.

In 1968 two galaxies (Maffei 1 and 2) were discovered on infrared plates, and it was proposed in 1970 that they too belonged to the Local Group. However, more recent distance determinations place Maffei 2 about 15 million light-years away — much too distant to belong to the Local Group which has a diameter of only about three million light-years. Maffei 1 is a giant elliptical galaxy considerably closer than Maffei 2, but probably still beyond the three million light-year limit.

Earth's "Plasma Mantle" Studied

The picture of Earth's magnetic field has grown still more complex with the discovery by a German research team of what they term a "plasma mantle" flowing toward the "tail" of the field just inside the boundary between the magnetosphere and the solar wind.

Revealed in a study of 1972 data from the European Space Research Organization's HEOS A-2 satellite, the plasma mantle seems to be a persistent phenomenon extending over the entire "tailward" portion of the magnetosphere on the northern side of the plasma sheet. Its thickness seems to range up to as much as four Earth widths.

Observed for nearly 11 months, the plasma mantle had a typical flow speed of 100 to 200 miles per second. The most likely cause of the phenomenon is the merging of terrestrial and interplanetary magnetic fields on the day side of Earth.

Unusual Sun Oscillation Reported

Dr. Henry A. Hill, University of Arizona physicist, has reported observations showing the sun oscillates much like a giant mass of jelly.

Hill said he has determined the sun pulses simultaneously at several different frequencies, with the slowest pulsation yet observed requiring approximately 50 minutes to complete a cycle.

"It is extremely difficult to assign accurate amplitudes to these motions, but they are certainly quite small," Hill reported to the National Science Foundation which funded his research. "The largest of them currently is estimated to change the sun's diameter by no more than six miles, or one part in 100,000."

A greater understanding of the sun's physical properties is important since it will enable astronomers to have a clearer understanding of the internal structure and fundamental processes of distant stars.

Theorists have speculated since the turn of the century that the sun might be oscillating, much as Earth does after an earthquake. Oscillations could be stimulated from time to time by violent activity normally found on the sun's surface. Once started, some solar physicists theorize the oscillation might continue indefinitely — powered by energy which constantly diffuses out from the sun's interior.

Although the changing shape of the oscillating sun can be measured, the associated changes in brightness have proven too small to be seen through Earth's turbulent atmosphere.

The oscillations could give some clues to help solve the puzzle of missing neutrinos (massless, chargeless particles resulting from nuclear reactions occurring in the sun's core), which serve as a barometer of the activity and energy output of the sun. Neutrino detectors have set the upper limit on neutrinos coming from the sun at 1/5 the calculated number. Why this is so has not yet been determined.

The observations were made at the Santa Catalina Laboratory for Experimental Relativity by Astrometry (SCLERA) — located on an 8,500 foot peak about 35 miles north of Tucson, Ariz. — using a specially designed five inch vertical telescope in a 50 foot tower. The optical and electronic detectors of the instrument (designed by Hill) are housed in a vacuum chamber, providing temperature stability and low light scattering.

Hill said the finding was an unexpected offshoot of a program concerned with testing theories of gravitation demanding accurate measurements of the sun's properties.

Despite the small size of the sun's pulsations, Hill said they can carry much information concerning the distribution and properties of the material within the sun. For many years, geologists have studied Earth's interior by observing seismic oscillations caused by earthquakes or artificial means. The oscillations observed at SCLERA should allow solar physicists to study the sun's interior in much the same way. In this sense, the oscillations may provide a window to the previously invisible solar interior.

"At this time," Hill said, "the only other experiment that offers such a direct view of the solar core is Dr. Raymond Davis' solar neutrino detector in Lead, S.D. The results of that experiment have been so surprising and difficult to understand that an independent method of probing the center of the sun is especially welcome."

It may be several years before the importance of these oscillations can be assessed, because the problems of analysis and interpretation are complex and the ramifications in other astrophysical fields may be far reaching. They could be one of the most useful and informative tools for understanding solar and stellar structure appearing in recent times.

Carbon Monoxide Gas Studied In Distant Exploding Galaxies

Radio signals emitted by clouds of carbon monoxide gas in two dusty, exploding galaxies (M-82 and NGC-253) more than 10 million light-years from Earth have been recorded by a specially designed telescope atop Kitt Peak (Ariz.).

Scientists expect that the discovery will open the way to studying the detailed motions of gas clouds among the stars of the two churning galaxies. Studies of the distribution of carbon monoxide gas, which is common in our own galaxy, may reveal the abundance of different types or isotopes of carbon and oxygen in distant star systems.

The discovery of the carbon monoxide molecules [starting with hydroxyl (OH) radicals in 1963] is considered one of the major surprises of modern astronomy. The gases are most dense in regions surrounding the cores of galaxies where the formation of stars and presumably of planetary systems is most frequent.

Radio waves from clouds of gases such as carbon monoxide thus provide a clue to what is going on in the densest and most active regions of star systems or galaxies.

New Methods Sought for Life Detection

A $50,000 contract to study new methods for detecting life on other planets has been awarded to TRW Systems by NASA's Ames Research Center. A method of detecting materials allowing scientists to infer the presence of life without actually seeing living creatures is the main emphasis.

"We'll study ways to detect amino acids — the so-called building blocks of life — using highly sophisticated and complex chemistry experiments," says Steve Korn of TRW Systems. "We aren't trying to maintain life or incubate living organisms as Viking (mission to Mars) will."

On Earth, amino acids take two distinctly different forms — "left" and "right" handed. Several meteorites have been recovered that contain both left and right handed amino acids, indicating a nonbiological origin.

"We'll be looking for these amino acids, and the structure they take," Korn says. "From this, scientists should be able to infer the presence or absence of biochemical activity and hence life."

NASA has no current funded plan beyond Viking to search for life on other planets. The TRW contract is part of a continuing effort by NASA to advance technology in a variety of scientific disciplines.

The Crab nebula (M-1) in Taurus is a proven cosmic ray source. Lick Observatory photograph.

Cosmic Ray Distribution And Origin Determined

Discovering the source of cosmic rays (energetic particles combarding Earth uniformly from all directions in space) has been the central problem of high energy astrophysics for over a generation. But recent satellite observations of the distribution of gamma rays and galactic gas has deduced galactic cosmic ray distribution.

This distribution, identical to that of supernova remnants, strongly supports the hyphothesis that most observed cosmic rays are produced by supernovae in our own galaxy, according to Floyd W. Stecker of the theoretical studies group at NASA's Goddard Space Flight Center.

Evidence accumulated in the last two years indicates the Crab nebula and the Vela supernova remnant produce cosmic rays. But questions of how typical these two young, nearby supernovae remnants are and the validity of conclusions that galactic supernovae are cosmic ray sources were raised. Whether cosmic rays emanate from within our galaxy or from outside was also a question.

Observations made by a gamma ray telescope on the SAS-2 (Small Astronomy Satellite) may have settled the matter. Galactic gamma rays result primarily from the decay of subatomic particles produced when cosmic rays interact with interstellar gas. Gamma rays are thus a tracer for cosmic rays; they travel in straight lines undeterred by magnetic fields.

Stecker determined from these observations that the galactic cosmic ray distribution is not uniform (as indicated by the extragalactic origin hypothesis). He saw "a striking similarity" between cosmic ray distribution and supernova distribution in the galaxy. "It is a remarkable agreement," he says, and constitutes "very strong, almost conclusive evidence that cosmic rays are produced in the same regions as supernovae, which are the only logical galactic events able to produce particles of such energy."

New Satellite Series Will Investigate Deep Sky Objects

High Energy Astronomy Observatories (HEAOs), managed for NASA by the Marshall Space Flight Center in Huntsville, Ala. and built by TRW Systems, are taking shape as a new series of satellites which may improve man's understanding of the universe. Spacecraft testing and integration will begin early in 1976.

The three HEAO observatories will scan the sky from 225-nautical-mile Earth orbits studying neutron stars, quasars, pulsars and black holes. The observatories will search for clues to help trace the evolution of stars, galaxies and perhaps the universe itself.

HEAO-A, the first of the trio to study these high energy radiation sources, will be launched in April 1977. It will carry four instruments to conduct an all-sky survey of radiation ranging from soft x-rays to higher energy gamma rays, accurately locate x-ray and gamma ray sources, and provide crude spectral data for studying the physics and evolution of energy sources.

The HEAO-B observatory houses a large x-ray telescope with a grazing incidence collector. It precisely points the telescope at celestial sources and focuses the x-rays onto a variety of scientific instruments, making detailed measurements of source location, structure, spectra and time variability of x-ray objects.

HEAO-C will conduct a scanning mission similar to HEAO-A. Two cosmic ray experiments and one gamma ray spectrometer experiment are included to obtain high spectral resolution data from gamma ray sources plus isotopic composition, charge and energy spectra of charged cosmic ray particles.

The high energy radiation emitted by some celestial objects — including quasars, pulsars, neutron stars and black holes — must be studied from space since it does not penetrate the atmosphere. A similar situation is also true for cosmic rays.

In addition to collecting new information on the origin and evolution of the universe, HEAO may develop new theories about the physics of energy production.

Powerful X-Ray Emissions Generated From Unknown Source in Orion

An event generating x-ray emissions five times greater than any observed before in the heavens has been detected in the constellation Orion.

The original observation was made in August by the British satellite Ariel 5, launched into Earth orbit in October 1974 from the Italian space launching platform in the sea off Kenya. When first detected, the x-ray emissions were weak. However, their intensity increased rapidly.

Soon they were recorded by SAS-3, the Small Astronomy Satellite launched from the same platform a few months ago.

The emissions were not shining directly into the satellite's detection system. It was assumed they came from the sun, which was active and emitting rays.

When first recorded by SAS-3, the emissions were only half as intense as those from SCO X-1 (an x-ray source in Scorpius long regarded as the most intense in the sky), but they soon became five times as strong.

With SAS-3 it has been possible to pinpoint their location to within one or two minutes of arc. This is the first time a reasonably accurate position for such an event has been available in time for ground based observatories to seek it out. The x-rays cannot penetrate Earth's atmosphere and accordingly must be observed from space. Therefore, the optical and radio observations could help explain the phenomenon.

About a dozen such "transient events" or surges of x-ray emission have been observed since Earth satellites made such observations possible. The most popular explanation is that the surges occur when an extremely dense object — such as a star formed chiefly of neutrons — is circling a normal but very large star.

In some cases the object may be a black hole — so dense that its gravity prevents emission of light. The x-rays would be emitted by masses of material falling from the large star toward its dense companion and then being heated to extremely high temperatures.

Evidence for such a situation would consist of rhythmic fluctuations in the x-ray emissions or in wavelengths of light from the star as the objects circled one another. Such fluctuations have been observed in other x-ray sources, but they have not been detected in the Orion area.

Pioneer Venus Probe Suffers Large Cutback

The U.S. House of Representatives recently cut $48 million from NASA's Pioneer Venus project which called for development of two unmanned space "busses" to orbit Venus in 1978 and launch several atmospheric probes. Experts suggest the mission could give an overall picture of Venus' prevailing weather patterns.

Efforts are currently underway to persuade the Senate appropriations committee to restore the Pioneer money, since a $48 million cut would postpone the Venus missions until 1980. Because of the increased distance between Earth and Venus in 1980, the Pioneers would require more energy than needed in a 1978 flight to reach the planet and decelerate into orbit. This means an expensive and substantial redesign of the current Pioneer spacecraft to make room for increased fuel capacity for braking maneuvers. This would reduce the number of scientific experiments carried on board, and in addition, existing Pioneer contracts would have to be canceled.

The Pioneer Venus cutback raises serious questions about NASA's ability to develop long-range planetary exploration programs. Pioneer Venus has already been under development for four years, characterized by extreme sophistication and a low budget ($170 million). NASA believes jeopardizing the project now wastes time and effort that has already gone into its development.

The House appropriations bill report accompanying the budget cut implies Pioneer Venus was delayed in order to strike a more equal balance between NASA's planetary astronomy and deep space astronomy programs. Astronomers favoring deep space research have criticized NASA for being preoccupied with planetary exploration. This criticism intensified after the Large Space Telescope (LST), a major deep space project, was nearly cut from last year's NASA budget.

To avert this competition between planetary scientists and deep space researchers, several prominent astronomers are expressing support for restoration of the Pioneer Venus budget. Princeton's Lyman Spitzer, a strong backer of the LST, recently told space exploration critic Senator William Proxmire (D-Wisc.) that delaying Pioneer Venus would be "a serious mistake".

Supernovae May "Dig" Network Of Extensive Galactic Tunnels

Our galaxy may be honeycombed with a network of hot tunnels dug by supernovae, according to a new theory presented in the **Astrophysical Journal**.

Exploding supernovae produce an expanding blob of hot matter. This pushes outward against the cooler interstellar matter surrounding it, forming a kind of bubble in the interstellar medium. When the bubble gets big enough, the matter in it is much thinner than in the surrounding medium. The cavity lasts for at least four million years.

During this time other supernovae are exploding, and if a new supernova bubble breaks into an old cavity, the new explosion's shock wave will be driven into the old cavity.

Chances are even greater that the cavity will be hit by a third explosion. Gradually, tunnel chains would form. Even a supernova rate of one in 50 years would be enough to interlace the galaxy with a network of tunnels. Evidence for such a network may already be observed in features of X-ray emission, ultraviolet absorption and hydrogen distribution in interstellar space.

Intruder From Another Universe?

A pulsar — a 10 mile wide ultracompact remnant of an exploded star — has recently been discovered to have properties that make it seem to be an intruder from another universe. This conclusion is so bizarre and unpalatable to astronomers that other explanations are being sought.

Pulsars have fascinated astronomers from the time of their discovery to the present. When the rhythmic bursts of radio noise from these objects were first observed in 1967, it was speculated that we were detecting signals from an extraterrestrial civilization. The first two pulsars were given the code names LGM-1 and LGM-2, where LGM stands for "little green men".

As time went on, less exotic explanations were advanced; we have now accepted the picture of a pulsar as a very compact star — a neutron star — in rapid rotation. The radio signals originate from a cone of high energy radiation that rotates with the star. Each time this celestial lighthouse beam points towards Earth we detect a signal. As energy is lost from the pulsar, its rate of rotation slows; thus the regular signals increase in period.

One particular pulsar, JP-1953 in Cygnus, is an oddball for which virtually no detectable decrease in rotation has been observed. If JP-1953 has always had the infinitesimal rate of slowdown that we observe now, then it is an extremely old object. The figure of 45 billion years has been suggested for JP-1953's age, making it older than the rest of the universe!

If this analysis is correct, then somehow JP-1953 survived the primeval fireball of the big bang when the rest of the universe was formed. In the simplest calculated models of the big bang, all matter loses its identity, and we would expect nothing to survive. However, we have not had much experience with big bangs and our models of the primeval fireball may be too unsophisticated. Perhaps pockets of matter can survive the fireball, and the material of JP-1953 is in fact from another universe.

Of course, there are various other explanations for this unique pulsar with the most prosaic being that it is surrounded by a much weaker magnetic field than any other pulsar. A magnetic field retards the pulsar's rotation, a weak field affecting a pulsar much less drastically than a strong one. A more far-out explanation is that JP-1953 is a white dwarf rather than a neutron star. Theoretically, some white dwarfs could originate pulsating radio waves. None of the explanations satisfy a majority of astronomers so, for the present, JP-1953 can only be classed as an unexplained celestial phenomenon.

Light Near Quasar Determined to be Hot, Moving Gas

A faint wisp of light near one of the earliest known quasars (3C48) is hot gas which, according to a team of Lick Observatory astronomers, apparently moves in, out and around the quasar at 1.25 million m.p.h.

Sensitive equipment on Lick Observatory's 120 inch telescope measured the light's properties. Much controversy has centered on quasars since their discovery 12 years ago. These faint starlike objects have very large spectral redshifts, indicating they are the most distant known objects in the universe. Yet, 3C48 is one of few quasars to have a "fuzz" of light around or near it. Giant galaxies at great distances have been suggested as the source of this faint wisp of light.

The team believes, however, the fuzz near 3C48 comes from hot gas having a slightly greater redshift than the central object. This difference in redshift, if due to velocity, corresponds to a speed of 1.25 million m.p.h.

More than 100 times fainter than 3C48 itself, this feature lies only a few seconds of arc away from the quasar. Measuring a faint light so near a much brighter object was possible with a sophisticated computerized detector. City light pollution near the observatory is accurately subtracted from the signal. Then the detector scans and analyzes the light source.

In 3C48 the wisp has a larger redshift than in the central object. This redshift cannot be caused by a strong gravitational field (such as in a black hole) in the center of the quasar. If such a field existed, the redshift would be smaller in outlying regions.

Gravitational redshift is still a possible interpretation for quasars with redshifts larger than that of 3C48.

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Solar System Creation Outlined

A new theory on the creation of the solar system includes a tremendous explosion of a giant star — with its core slamming backwards into our sun and reversing the direction of its rotation.

"Among other things, this theory explains the origin of the chemical elements above hydrogen in the planets," according to its originator, Judd Boynton of Geophysics Labs and Research in Berkeley, Calif. "All of the chemical elements above hydrogen had to be created via nuclear fusion within the stars," Boynton added.

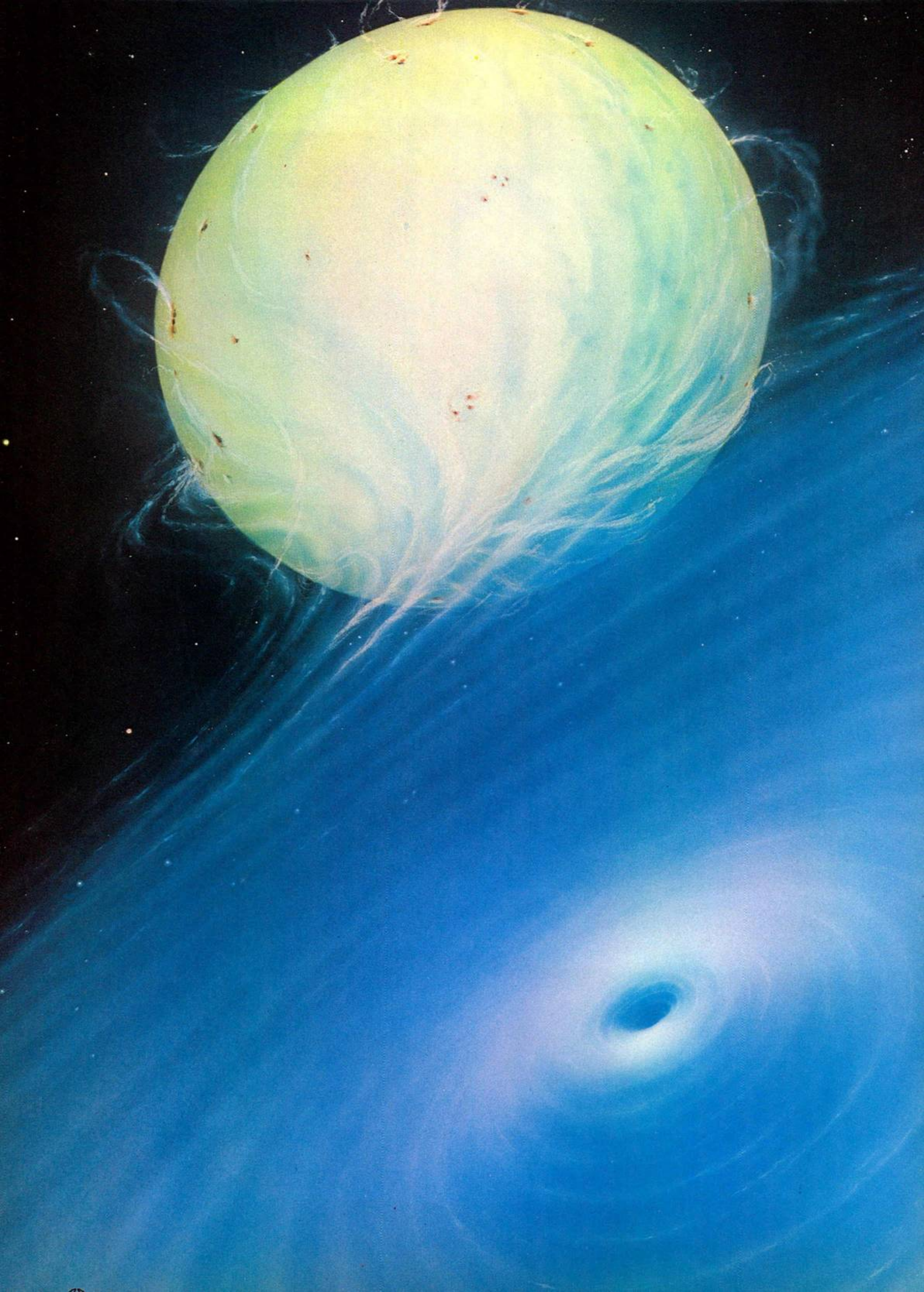
The creative process started 4-1/2 billion years ago when an iron-rich companion star, 5 to 10 times more massive than the sun, exploded as a consequence of "runaway" internally generated nuclear fusion.

The blast blew more than 99.9 percent of the mass outward into space. The residue eventually was pulled together to form the planets of the sun, their moons and the asteroids.

Implosion of this event formed a dwarf companion to our sun. This dwarf was blown backwards in relation to its original orbit and moved ever closer to the sun.

Finally this dwarf entered the sun, skimming the surface at orbital velocity and reversing the sun's rotation.

The violent energy exchange in this "splashdown", combined with the dwarf's high density mass, caused distribution of the mass equatorially around the sun and gave that body a "gravitational squeeze" around its equator. This explains why the sun has an elongated diameter at the poles instead of the expected equatorial bulge. It also accounts for the current differential rotation of the sun — a 25 day rotational period along the equator as opposed to a 30 day period at the poles.



STELLAR FRONTIERS

Two X-Ray Stars

by

Gerrit L. Verschuur

On a cosmic scale, x-rays fill the universe around us, continuously reaching Earth from outer space. Many celestial objects — our sun, several types of stars, extragalactic objects (galaxies and quasars) — emit x-rays in varying degrees. X-radiation from the sun alone would endanger all living creatures on our planet if it were not for the shielding effect of Earth's protective atmosphere. Only recently has man been able to discover strange deep space x-radiation sources by means of detectors mounted on rockets and satellites propelled above Earth's atmosphere.

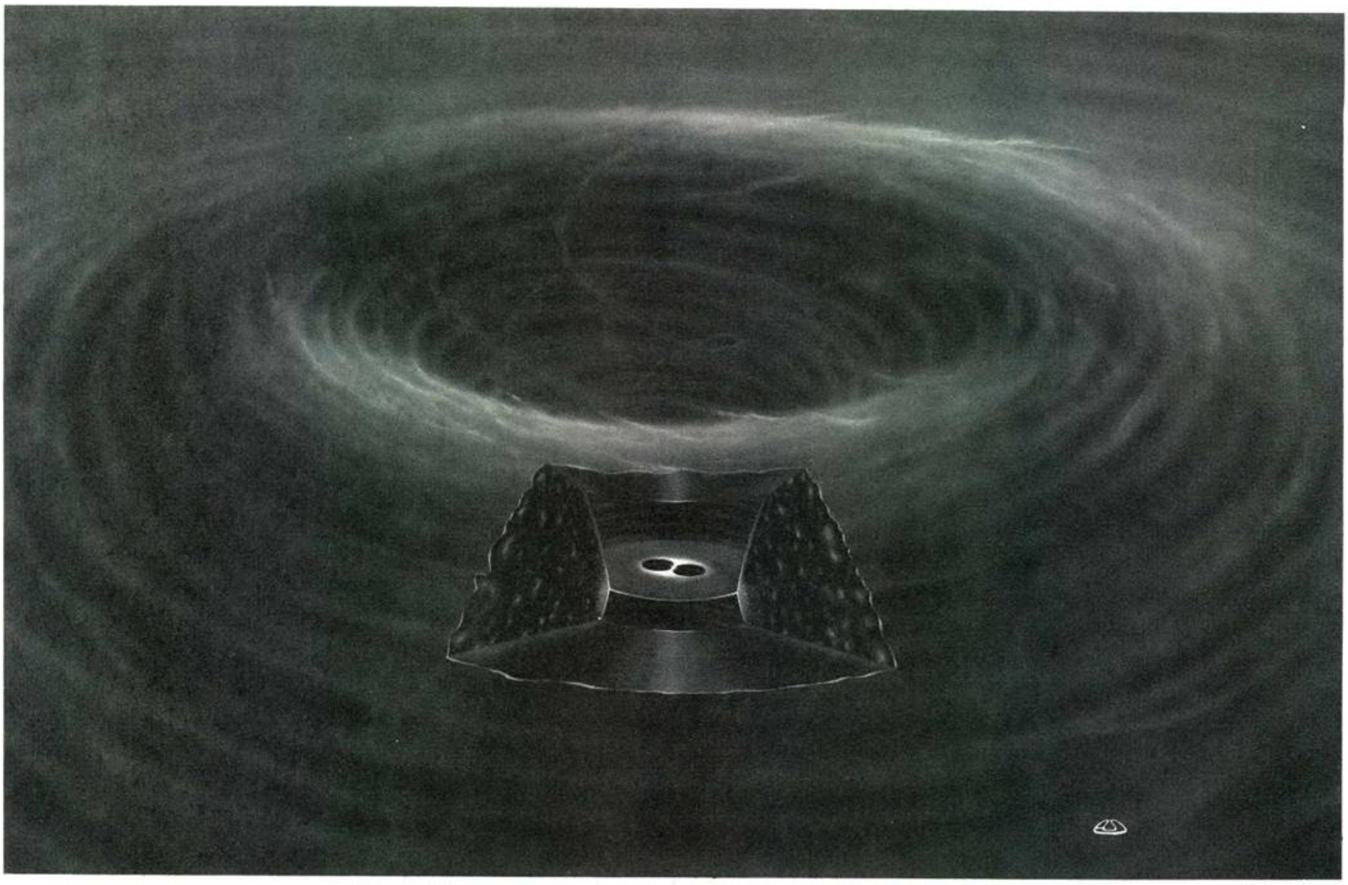
In 1963 the first rocket x-ray equipment detected a strong x-ray source in the constellation Scorpius. The source, Sco-XI, is so intense it even affects Earth's ionosphere. In 1970, the x-ray satellite Uhuru started mapping the x-ray sky. To date, 160 x-ray sources have been located; 100 are within the Milky Way, and the rest are extragalactic objects.

Two of the Milky Way's most interesting x-ray sources are members of binary star systems. Hercules X-1 (Herc X-1) is a neutron star, and Cygnus X-1 (Cyg X-1) is a black hole. Both orbit normal suns.

Matter from the F-type component in HZ Herculis streams down into the disk of Herc X-1, emitting x-rays as it falls to oblivion into the neutron star at the core. HZ Herculis shows several other variabilities in x-ray emission due to its neutron star companion. Artwork by Adolf Schaller.

Most x-ray sources in the Milky Way are members of binary systems. In each case, the x-ray "star" orbits a fairly normal star so closely that gas from the normal star streams toward the small and very massive companion. As this gas falls into the smaller neutron star or black hole, it heats to such great temperatures that x-rays are emitted. How do we know this process occurs? Let's examine each of the two x-ray stars separately.

X-ray source Hercules X-1 is thought to be a neutron star. Matter in a neutron star has been crushed; its basic particles (electrons and protons) have coalesced, forming a sea of neutrons. (If the sun were compressed to a ball about six miles in diameter, it would be a neutron star.) A neutron star's enormous gravitational attraction can disrupt matter striking it. If a small object (a marshmallow for instance) were dropped onto its surface, the explosion created on impact would produce as much energy as an atomic bomb. In fact, the energy released by dropping one gram of matter in this way is more than that released in the conversion of one gram of hydrogen to helium in the fusion process. The conversion of gravitational energy into radiation by this process is hundreds of times more efficient than nuclear processes generating heat and light in the sun. But how do we know that Hercules X-1 is a neutron star?



A close-up cut-away section of the Herc X-1 accretion disk reveals the tiny, but staggeringly powerful gravitational force at the core — a neutron star. Material blown off a companion (in this case an F-type star) is sucked into the gravitational fields of the neutron star, spiraling to its death and emitting x-rays as it does so. The neutron star's magnetic field is stronger than the gravitational force very near the star itself, and the gases are forced to follow the magnetic field lines ending at the surface of the star in two "hot spots" — each with an area of about a square mile. It is here and in the columns of turbulent gas above them that the x-ray emissions are formed. Artwork by Adolf Schaller.

The x-ray star Herc X-1 is a member of an optically visible binary system known as HZ Herculis. The visible component, an F-type star, exhibits a periodic brightness change every 1.7 days. Careful study of this periodicity and the star's distance allows astronomers to calculate the binary's physical properties — in particular, the invisible companion's mass (it is about as massive as the sun). Additional evidence about the x-ray star comes from a close study of its x-ray emission.

Intensity of x-radiation from Hercules X-1 shows very systematic variations. They "turn off" for five hours every 1.7 days because the parent F-star eclipses the x-ray star from our line of sight. Additional variation includes a pulselike burst of x-rays once every 1.24 seconds which indicates the x-ray source is spinning very fast. Any object equaling the sun's mass which spins once every 1.24 seconds can only be a neutron star (pulsar) or it would disintegrate. Additionally, detailed measurements show the pulse rates change from day-to-day as expected for an orbiting object with a period of 1.7 days.

Actual observations of HZ Herculis show matter streaming out of the star — a common occurrence in binary systems having close orbits. Some of this matter must be falling into the neutron star, emitting x-rays as it does so.

This matter transfer is a two step process. As stars evolve, they expand. Since the stars are in such a close orbit, the neutron star causes the other star to bulge outward a little. The combined effect of these two phenomena means matter from Hercules X-1 reaches the so-called *equipotential* surface (the region where the gravitational attraction from the two stars balances). Matter from HZ Herculis spills over this surface, gets caught by the gravitational pull of the neutron star and falls toward it. This matter spirals downward and occupies a disk shaped region around the neutron star.

In addition to the two periodicities mentioned, the system also shows a rather unusual emission cycle of x-ray pulses for 11 days and nothing for 24 days. This too has been explained in reasonable terms. The disk of matter around the neutron star produced by the material spiraling inward may be *precessing* — wobbling on its axis with a period of 35 days. For about 24 days, it blocks our view of the x-ray emitting regions, and for 11 days the x-rays manage to shine past the disk, making them detectable.

The x-rays from Hercules X-1 show at least these three very obvious periodicities. However, the intensity of the x-rays emitted in the pulses (between the 1.7 day eclipses during an 11 day on-cycle) also show some major dips — probably due to absorption by gas clouds on their way into the neutron star.

An additional interesting feature of Hercules X-1: The F-star, HZ Herculis, shows brightness variations in its orbit. The side of the F-star facing the x-ray star is hotter than the side facing away from it. Like all objects in such close orbits, the F-star keeps the same face toward the x-ray source all the time. The side facing the x-rays is heated to 10,000 degrees Fahrenheit (equivalent of an A-type star), while the other side is 7,000 degrees (normal for an F-type star). As it orbits the x-ray source, first its hot, then its cold side is seen by Earth observers with a period of 1.7 days.

Another important time scale has been found for Hercules X-1. The star HZ Herculis appears to have gone through 10 to 15 year periods when no 1.7 day variability was shown. This can only be explained if the x-ray source were to "turn off" for some reason. Then HZ Herculis would not have hotter and cooler sides. Why the x-rays switch off and then on again over these intervals is not understood.

Other questions can also be considered: Why are the x-rays pulsed? What does the rapid spin do? It does not explain why it should pulse more or less like a lighthouse beacon.

The picture suggested for the pulsing process involves the infall of gas along magnetic field lines of enormous intensity at the poles of the neutron star. At some point along these field lines, x-rays are generated as the matter heats up. However, these x-rays cannot escape out along the field lines because the infalling gas will absorb them. They therefore radiate only sideways. If the direction of the spin axis differs in the right way, we would only see pulses of radiation reaching Earth.

A final question: Since the neutron phase occurs at the end of a star's life, why does an old, small dying star (the neutron star) orbit a relatively young star? Surely the two must have formed at the same time to become a binary system in the first place.

Imagine that two stars are born together in close orbit. One star is very massive and the other about 1/4 as massive. Because the larger star has more material it burns faster as it grows older, and evolves much faster than the less massive star. Since it is so large, some of its material spills over into the star with less mass as in normal binary systems. As the massive sun ages, it swells to become a red giant, and more of its matter overflows into the smaller star's gravitational pull.

After this proceeds for several million years, the less massive star is larger than the former giant — which in the meantime has burned most of its hydrogen to form helium. It then starts burning helium, and after more millions of years it becomes an unstable object and explodes — forming a *supernova.*

The explosion hurls out most of the material in the once-huge star, and the remains (about half a solar mass) collapse to form a neutron star. The smaller sun is in a slightly different orbit after this explosion, but now the masses are again reversed — remains of the giant (a neutron star) have a more massive star orbiting it. Material from the larger sun starts spilling into the neutron star, producing x-rays. It isn't certain what happens after this. Possibly, the more massive sun might also become a neutron star or a black hole, and the binary would become invisible unless one or both became *pulsars* (spinning neutron stars that send out beams of light or radio energy). A binary pulsar has already been discovered. Some astrophysicists speculate there might be millions of dead stars like these in the galaxy even now which will never be directly discovered.

What about Cygnus X-1? It too has a visible companion, but this time it is a very luminous B-type star (HD 226868, ninth magnitude) located about 6,000 light-years from us. Estimates of its companion's mass result in a star at least eight times larger than the sun — and any star that huge, yet invisible and emitting x-rays, will be a black hole.

Matter from the B-type star is blowing out and falling into the companion black hole. A black hole is usually thought of as an object from which nothing can escape — including light and radio signals. X-rays would be in this category. But in the case of Cygnus X-1, it is matter on its way into oblivion that generates the x-rays, radiating its last sighs before disappearing forever. The x-rays are not created in the black hole, but near it.

X-rays from Cygnus X-1 show no regular periodicities like Hercules X-1. Instead, variations of x-ray intensity appear on all time scales less than a second or so — in particular around 50 milliseconds. Small irregularities existing inside the disk of matter surrounding the black hole (effectively the last of the orbit of gas falling into the black hole itself) have been suggested as the cause of the variations. But the precise nature of Cygnus X-1 is not yet fully understood.

It is amazing so much can be learned about apparently mysterious phenomena discovered only a few years ago by examining measurements made on Earth of objects located thousands of light-years away. Clearly, the future of x-ray astronomy will be incredibly exciting if it becomes possible to study conditions around black holes and neutron stars. Some astronomers hope this will offer even more valuable clues to other incredible cosmic emission sources such as quasars.

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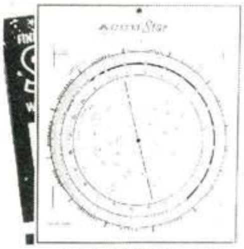

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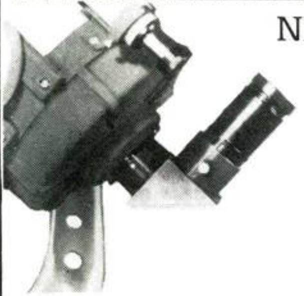

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STAR DOME

NOVEMBER

Crisp, cool fall nights signal the setting of the ever-familiar summer triangle, now just above the western horizon. Deneb gleams highest in the sky as Cygnus the swan wings his way westward, escaping the coming winter. Aquarius the water carrier now tips his water jar over the edge of the western sky, while Pisces the fish, bound by their strand of seaweed, follow dutifully behind nestled next to the great square of Pegasus.

High overhead lie the members of the royal family: Andromeda (whose head is Alpheratz, the top left hand star in the great square of Pegasus), Cassiopeia (queen of Ethiopia), Cepheus (king of Ethiopia), and finally the farthest constellation west, Perseus — husband of Andromeda — who appears to be reaching for her foot in the sky.

Perseus and his bride met in an unusual way according to mythology. Beautiful Andromeda nearly lost her life to a sea monster (the constellation Cetus, located below Pisces) when her mother, vain Cassiopeia, insulted the Sea Nymphs and incurred the wrath of Neptune. Neptune struck Ethiopia with famine and disaster and decreed that the terror wouldn't end until Andromeda was sacrificed to Cetus on the seashore. Cepheus had no choice but to sacrifice the young princess, and chained her to a rock on the coast to await her fate.

But Perseus came to the rescue. The young prince, returning to his home country after slaying the Medusa (a hideous creature whose gaze turned men to stone), spied the beautiful maiden on the beach and came to her aid. Cepheus was so pleased with the turn of events, he offered Perseus Andromeda's hand in marriage. Perseus accepted and returned to his home with his bride. Both constellations merely skim the horizon in springtime — two of the well-known circumpolar star groups in the northern sky.

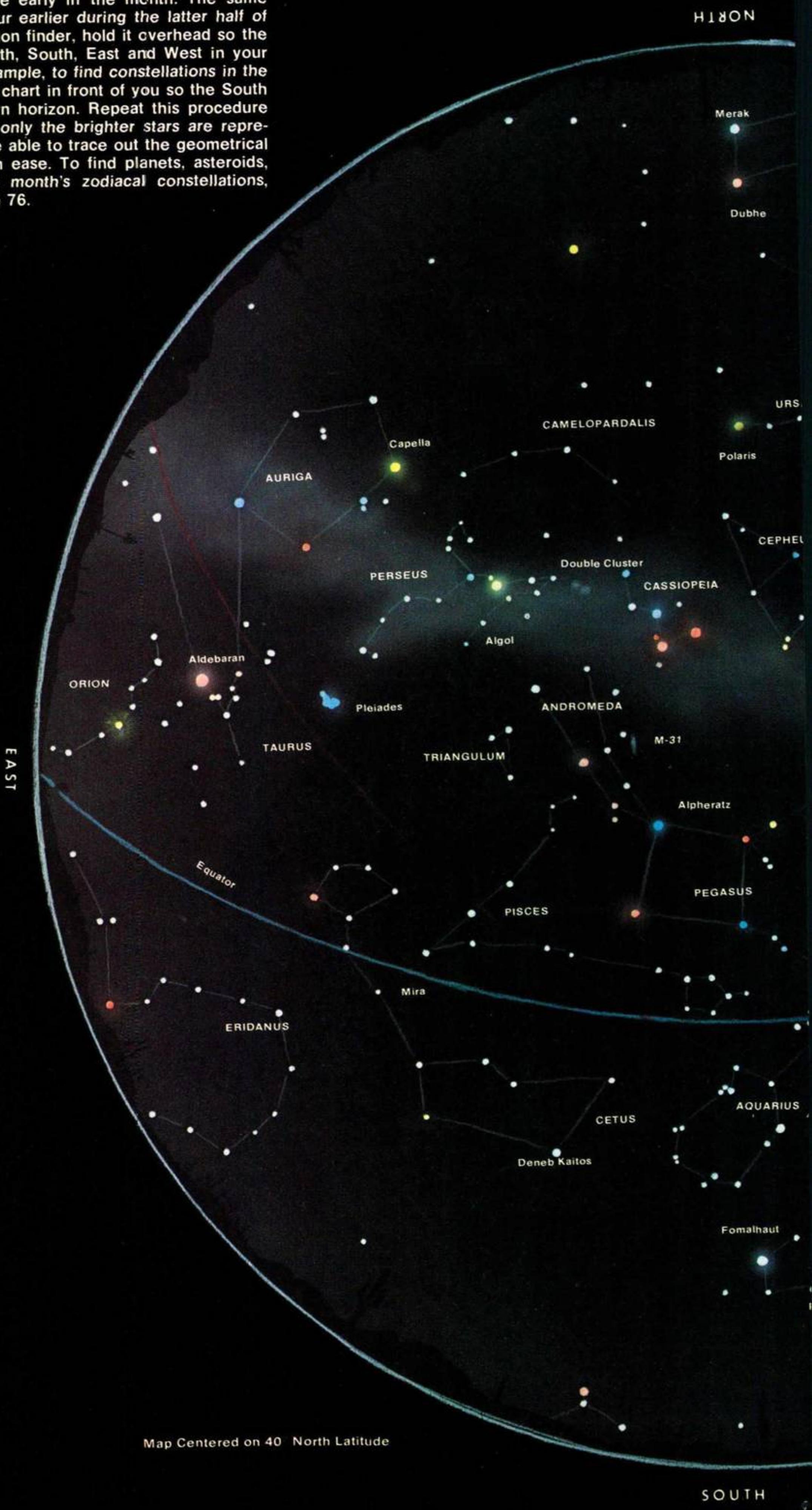
Directly below Andromeda is the topmost and smallest of the two fish in the constellation Pisces. The constellation is a large one, spreading across the fall skies in an area known as the sea. This portion of the heavens contains a number of constellations associated with water — Capricornus, Aquarius, Pisces and Cetus.

Linking Venus, Greek and Roman goddess of love, and her son Cupid with a pair of fish seems slightly unusual — but a Greek myth manages to do so. Venus and her son were walking one day on the banks of the Euphrates River when suddenly the terrible giant Typhon (known for his ability to appear at the wrong time) came along. Venus and Cupid, caught totally unaware, plunged into the Euphrates and changed into fish to escape the giant. Minerva was so impressed with the quick thinking of her compatriot goddess she placed the images of the fish in the sky to commemorate their clever getaway. Pisces has the additional distinction of containing the *vernal equinox*, the point at which the *ecliptic* (path of the sun in the sky) crosses the *celestial equator* (projection of Earth's equator onto the celestial sphere). It is at this point that the sun comes from below the equator to above — and spring begins.

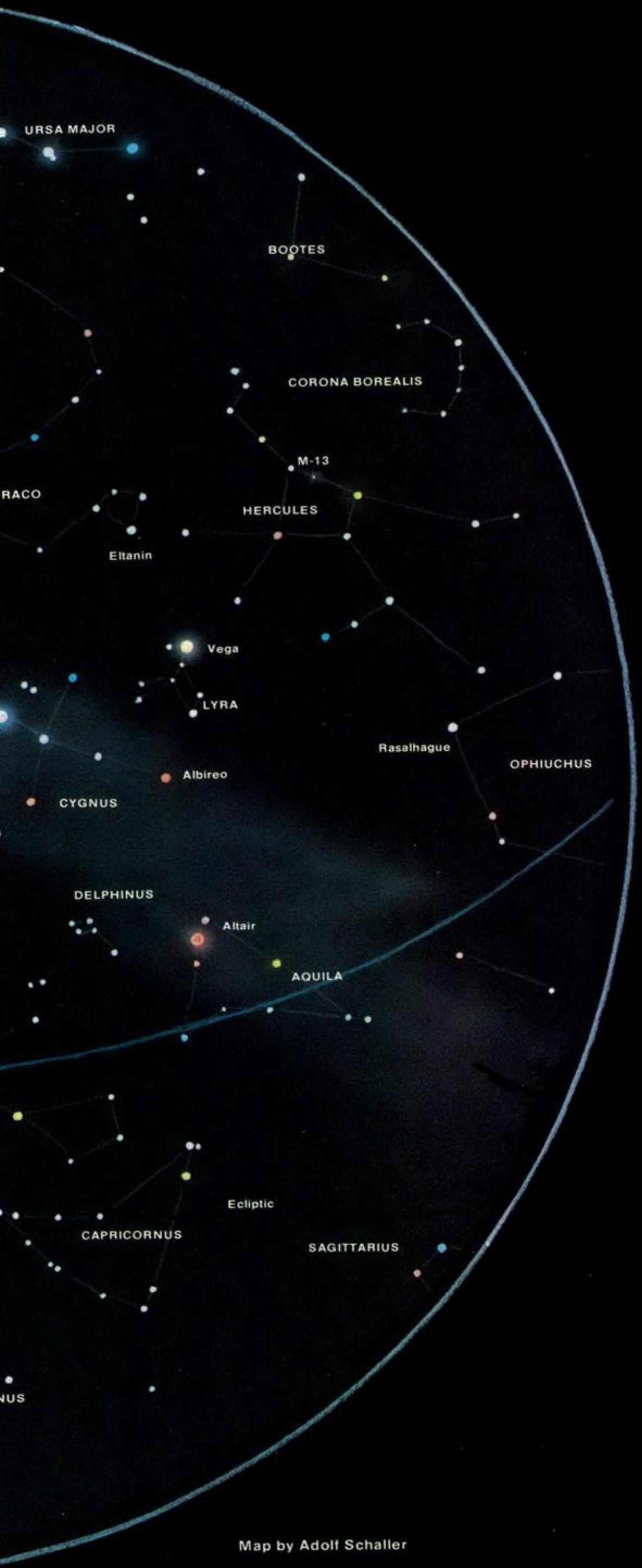
Following behind the huge constellation Pisces is Aries the ram, a tiny, nondescript group of stars containing no distinctly brilliant suns. The ram is important because of its position in the zodiac, and also for the rich celestial lore attached to it.

Aries represents the ram of the golden fleece, sought by the heroic band known as the Argonauts.

This Star Dome rendering approximates the sky as it appears at about 8 p.m. Local Standard Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 76.


NORTH
Merak
Dubhe
URS
CAMELOPARDALIS
Polaris
Capella
AURIGA
CEPHEU
Double Cluster
PERSEUS
CASSIOPEIA
Algol
Aldebaran
ORION
Pleiades
ANDROMEDA
M-31
TAURUS
TRIANGULUM
EAST
Alpheratz
Equator
PEGASUS
PISCES
Mira
ERIDANUS
AQUARIUS
CETUS
Deneb Kaitos
Fomalhaut
SOUTH

Map Centered on 40 North Latitude



Map by Adolf Schaller

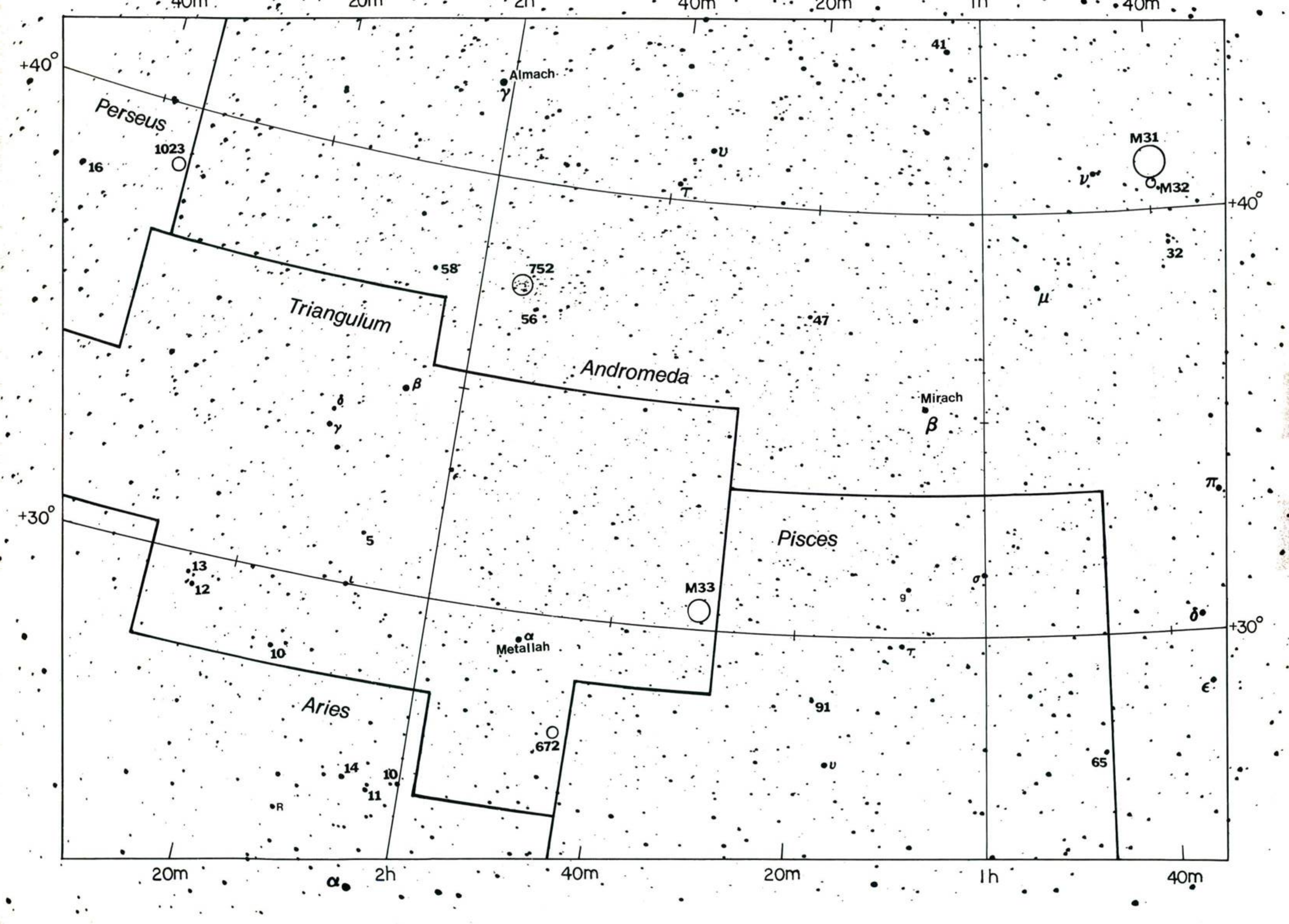
The ram was a gift from the god Mercury to Phrixus and Helle, children of King Athamas of Thessaly. The children were victims of a cruel stepmother, and Mercury sent the ram to rescue them from her. The creature had the ability to fly; with the children aboard his golden back, he began a journey to Colchis at the eastern end of the Black Sea. But Helle could not hang on as the ram crossed the strait dividing Europe and Asia and fell to her death in the sea. From then on, the strait was known as Hellespont. It is better known today as the Dardanelles.

When Phrixus landed safely at Colchis he sacrificed the ram in gratitude for his escape, and gave its fleece to Aeetes, king of that country. Aeetes hung the golden hide in the sacred grove of Aries, where it was guarded by a dragon which never slept.

Jason, the son of Aeson and Polymede, was ordered by Hera, queen of the gods, to obtain the golden fleece and free the kingdom of Iolcus from a curse. With this in mind, Jason called for volunteer sailors to go with him (among them were Hercules and the Gemini twins). The men of the Argo, as the ship was called, faced many terrible trials before obtaining the fleece. When they at last reached Colchis, Medea, daughter of Aeetes, fell in love with Jason and helped him obtain the golden hide by soothing the dragon (born from Typhon's blood) to sleep. Jason grabbed the fleece and ran for the ship, returning home by the same terrible route. He took Medea with him, as well as the fleece. The king of the Greek gods, Zeus (Roman god Jupiter), placed the ram among the stars to commemorate the thrilling quest of the Argonauts.

In the west, the great circle of first magnitude stars so prominent in winter is beginning to rise as the November nights progress. Capella, the goat star, is highest in the sky of this group. This brilliant yellow sun is the sixth brightest star in the sky, shining with a magnitude of -0.6. Using the word "sun" (when referring to Capella) is far from inaccurate for it is classified as a G2 star very similar to the sun in our solar system. Located only 14 parsecs (about 800 million miles) away, Capella is 150 times brighter than the sun, and is really a double star too close to be seen except with a spectroscope. The pair orbit a common center of gravity in 104 days, are in approximately the same physical condition and have about the same mass. Aside from its physical properties, the Greeks claimed the yellow star was the she-goat which suckled the infant Zeus, who later became king of the ancient gods.

As the evening progresses, other stars in the great circle become more dominant. Aldebaran (eye of Taurus the bull), Rigel (knee of Orion the hunter), Sirius in Canis Major (low on the horizon), Procyon in Canis Minor and Castor and Pollux of the Gemini twins — all are heralds of winter with the red giant Betelgeuse shining from the middle of the circle.


40m
20m
2h
40m
20m
1h
40m
+40°
+30°
Perseus
16
1023
Almach
γ
41
υ
τ
M31
ν
M32
32
58
752
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μ
Triangulum
Andromeda
Mirach
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Close-Up on the Andromeda/Triangulum Region

Locating Andromeda and Triangulum on fall observing nights is easily done when the great square of Pegasus is used as a landmark. Andromeda's head — known by the Arabs as Alpheratz, or "the head of the woman in chains" — marks the upper left hand corner of the great square. This white star of spectral class B9 is a spectroscopic binary whose companion has a highly eccentric orbit and a period of about 100 days. The binary is approaching the solar system at a speed of about eight miles per second, shining at magnitude 2.0.

East of Alpheratz at almost equal distances are three other stars, all of which are second magnitude, followed by a fourth — Alpha (α) Persei at magnitude 1.7. These stars form the distinctive curve marking Andromeda in the sky. Third in this lineup is Mirach [Beta (β) Andromedae], a class M0 star, and fourth is Almach [Gamma (γ) Andromedae], featured in Eyepiece Impressions.

Just a short distance below and between Beta and Gamma Andromedae lies Triangulum, an isosceles triangle lying on its side. Beta (β) Trianguli is closest to Andromeda, with Gamma (γ) forming the other corner of the triangle's base. Alpha (α), sometimes called Caput Trianguli, forms the point of the triangle. All three stars have magnitudes between three and four.

Eyepiece Impressions

M-31, M-32, NGC-205

Our region this month is highlighted by one of nature's most imposing spectacles — a distant island universe of stars far beyond the limits of our own Milky Way galaxy, visible to the human eye without optical aid. This is the famed Andromeda galaxy, M-31, which ranks as the finest representative of its class in the sky.

To spot this remote star city, locate the stars Beta (β) and Mu (μ) in Andromeda which point directly to its position, slightly more than one degree west of fourth magnitude Nu (ν). There, an elongated blur of light greets the eye on dark, transparent nights. Slow sweeping back and forth across this object with 7 x 50 binoculars reveals its amazing size and brightness. Catalogs list M-31 as 160 by 35 minutes of arc in extent; the combined light of its stars glows at fourth magnitude. Skilled observers using binoculars and wide-angle telescopes have traced this spiral galaxy's glow to nearly 10 full moon diameters in the sky — even though it lies more than 2,000,000 light-years from us!

Webb called the Andromeda galaxy, "One of the grandest in the heavens; long, oval or irregularly triangular, ill-bounded, and brightening to the center." Barns adds, "The Great Nebula itself demands periodical observations under varying conditions to unfold the true glory of this celestial paragon...." He calls it a "fairly defined naked eye spectacle; but in a telescope of low power and wide range (field), an object of increasing interest and wonder."

A three inch refractor or four inch reflector at 45 power shows a small but bright nucleus surrounded by an eerie oval of light extending completely beyond the eyepiece field. This glow is the blended light of billions of distant suns orbiting the galaxy's center. Careful scrutiny also reveals dark structures or rifts above and below the nucleus — areas where the nebulosity suddenly ends — the actual lanes between the spiral arms.

With eight inch and larger instruments the tiny galactic core looks starlike, and the contrast between light and dark areas seems greater. The dark structure is best seen by averted (side) vision and slow sweeping back and forth across the galaxy with a low power eyepiece.

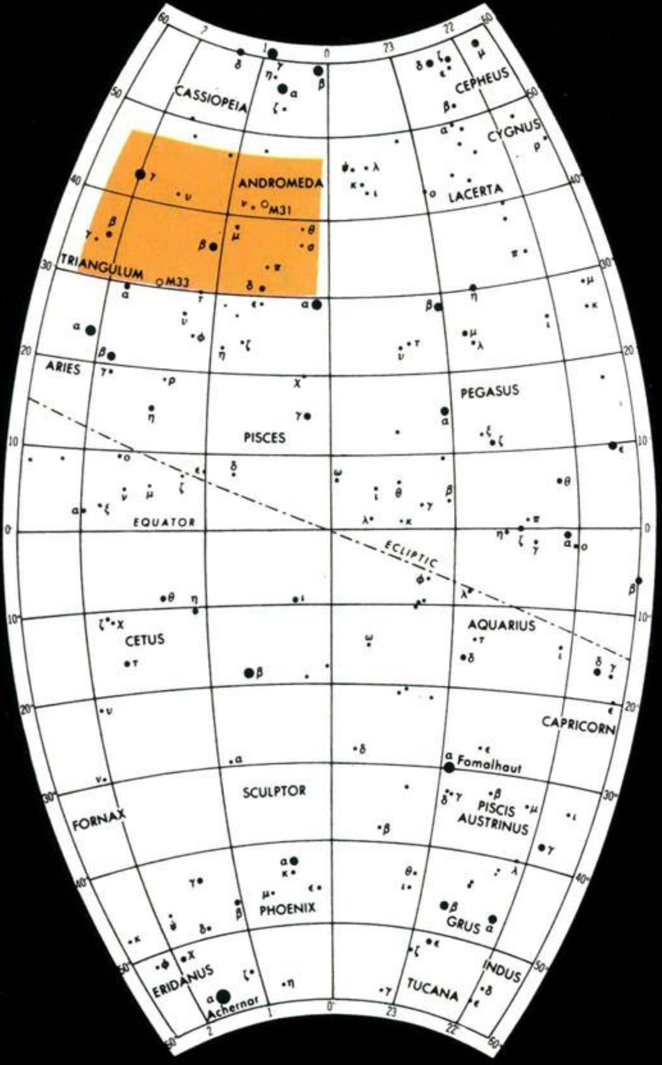
In addition to M-31 itself, a small round fuzzy spot can be seen in the field about 1/2 degree to the south. This is M-32, an 8.7 magnitude elliptical companion galaxy just three minutes of arc in diameter. And just over a degree northwest of M-31 is another elliptical companion known as NGC-205. This 10 by 4 minute, ninth magnitude glow has a very low surface brightness and is easily missed — especially in small telescopes. Barns describes it as "...large, oval, pearl white", while Webb says this object seems to sparkle. All three galaxies can be seen in a 2.4 inch (60mm) refractor using only 30 power.

As with other deep sky showpieces, it is fascinating to compare amateur and professional photographs of the Andromeda galaxy with its telescopic appearance. Surprisingly, a well-trained dark adapted eye on a good night can actually glimpse much of the detail seen in the photos.

M-31 is estimated as more than 100,000 light-years in diameter. Such vastness is frightening to some — but let's consider an amazing and perhaps significant fact. Nature's smallest basic building block is the atom, while its largest unit is the galaxy. The average human being is situated exactly midway in size in this incredible scale.

Gamma (γ) Andromedae

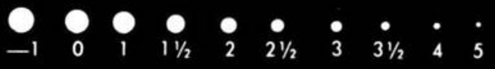
Turning our attention from this trio of galaxies millions of light-years distant to a trio of stars just hundreds of light-years away, we find the beautiful triple star system, Gamma Andromedae. Discovered as a double in 1788, Gamma A and B form one of the finest pairs in the entire sky for all telescope apertures.


CASSIOPEIA
CEPHEUS
CYGNUS
ANDROMEDA
M31
LACERTA
TRIANGULUM
M33
ARIES
PEGASUS
PISCES
EQUATOR
ECLIPTIC
CETUS
AQUARIUS
CAPRICORN
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
FORNAX
PHOENIX
GRUS
ERIDANUS
Achernar
TUCANA
INDUS
60
50
40
30
20
10
0
10
20
30
40
50
60
2
1
0
23
22

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet.

α	**Alpha**	η	**Eta**	ν	**Nu**	τ	**Tau**
β	**Beta**	θ	**Theta**	ξ	**Xi**	υ	**Upsilon**
γ	**Gamma**	ι	**Iota**	ο	**Omicron**	φ	**Phi**
δ	**Delta**	κ	**Kappa**	π	**Pi**	χ	**Chi**
ε	**Epsilon**	λ	**Lambda**	ρ	**Rho**	ψ	**Psi**
ζ	**Zeta**	μ	**Mu**	σ	**Sigma**	ω	**Omega**

Star Magnitudes


—1
0
1
1½
2
2½
3
3½
4
5

○ Cluster or Nebula

⊙ Variable Star

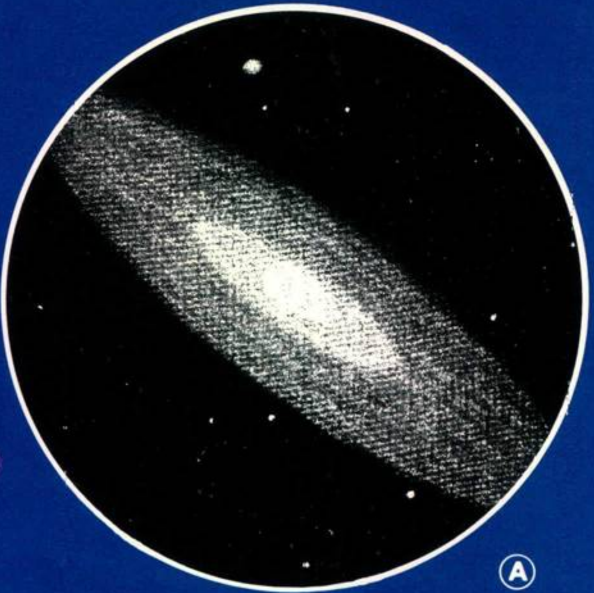
+ Nova

Map from **Guideposts to the Stars**; reprinted permission of MacMillan Publishing Co., ©1972 by Leslie C. Peltier.

TABLE OF OBJECTS — ANDROMEDA/ TRIANGULUM REGION

Object	Type	Magnitude	Size/Separation	R.A. (1950)	Dec.
π Andromedae	double star	4.4, 8.7	36"	00^h34^m	+33° 27'
* NGC-205 (Andromeda)	elliptical galaxy	9.4	10' x 4'	00^h38^m	+41° 25'
* M-31 (Andromeda)	spiral galaxy	4.8	160' x 35'	00^h40^m	+41° 00'
* M-32 (Andromeda)	elliptical galaxy	8.7	3' x 3'	00^h40^m	+40° 36'
* M-33 (Triangulum)	spiral galaxy	6.7	65' x 35'	01^h31^m	+30° 24'
56 Andromedae	binocular double star	5.8, 5.8	189"	01^h53^m	+37° 00'
*NGC-752 (Andromeda)	open cluster	7.0	45'	01^h55^m	+37° 25'
* γ Andromedae	triple star	2.3,5.5,6.3	10", 0.5"	02^h01^m	+42° 06'
59 Andromedae	double star	6.0, 6.7	17"	02^h08^m	+38° 48'
* ι Trianguli	double star	5.4, 7.0	4"	02^h10^m	+30° 04'
NGC-891 (Andromeda)	spiral galaxy	10	12' x 1'	02^h19^m	+42° 07'

* Detailed description in Eyepiece Impressions



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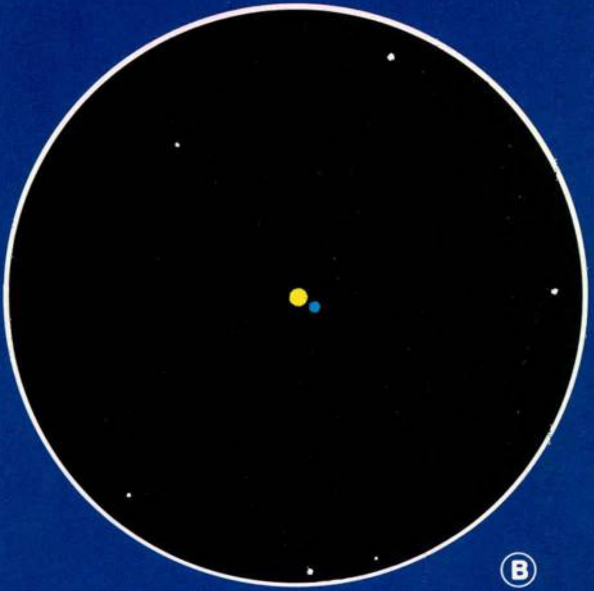

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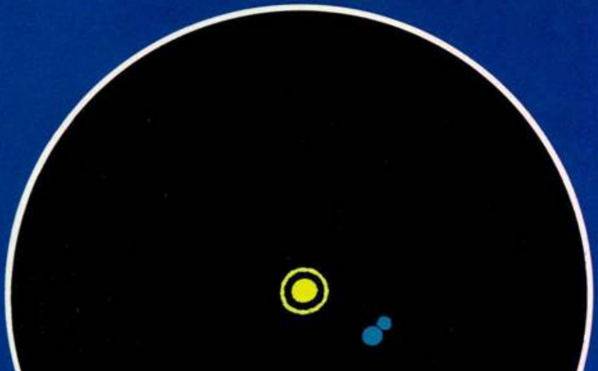


Ⓒ

(A) Two billion light-years away lies the Andromeda galaxy (M-31) and its two companion galaxies, M-32 and NGC-205. Larger than our own Milky Way galaxy, M-31 shows similar spiral structure. Our sister galaxy extends far beyond the one degree field as seen in an Edmund four inch reflector at 40 power. Skilled observers see great detail in this fuzzy, elongated patch of light. (B) Gamma Andromedae, a triple sun system with intense color contrast, is well seen in a Unitron 2.4 inch refractor at 70 power. The yellow-orange and blue-green components occupy the center of a 3/4 degree field in this case. (C) Another view of Gamma Andromedae, this time in a home built 4.25 inch off-axis refractor at 520 power, shows the triple system resolved in a field of view of five minutes of arc. Resolving the system is a fine test for small instruments at high power, requiring excellent seeing conditions and fine, well-conditioned optics. Artwork by James Mullaney.

Gamma is at the end of an arc of four naked eye stars extending northwest from the top left corner of the great square of Pegasus. The A and B components are 2.3 and 5.1 magnitudes and are separated by about 10 seconds of arc. Their contrasting colors are intense in even the smallest telescope; most observers see them as yellow-orange and blue-green. A 2.4 inch refractor at 70 power will give a thrilling view of this lovely duo.

Barns' description is "gorgeous coloring — burnished gold and cerulean blue". Smyth calls the hues "deep yellow and sea green", while Webb calls Gamma Andromedae "one of the most beautiful pairs in the heavens".

In 1842 the great double star abserver Otto Struve found that the B component is itself a close binary with an orbital period of about 60 years. The B/C pair consists of 5.5 magnitude blue and 6.3 magnitude green suns whose separation varies a few tenths of a second from 0.5 seconds of arc.

Webb says this close pair "forms an admirable test object", but cautions "it is important to note the difference between one long disk crossed by a dark interference line, which is simetimes called division, and two round disks with black sky between them." Good advice, for this object often looks egg shaped when seen in small instruments at high magnifications.

The close pair is notoriously difficult to resolve, requiring a trained eye, excellent optics and superb seeing conditions (image steadiness). Although difficult on many nights in a 12 inch reflector and 13 inch refractor at 600 power, they have been resolved in apertures as small as four inches using 500 power on nights of excellent seeing.

What about your telescope? Why not see if it can meet the celestial challenge presented by this tightly bound pair? Our drawing of high power views gives some idea of just what to look for.

NGC-752

Sweeping the sky with your finder or binoculars near the fifth magnitude star 56 Andromedae on a dark night will reveal a sparkling patch of light larger than the full moon. This is the loose open cluster NGC-752, shining with the combined light of a seventh magnitude star. Its many faint members (catalogs list at least 70) are scattered over more than 45 minutes of arc making this object easy to pass over.

A wide double, 56 Andromedae can be resolved in binoculars. A three inch refractor at 45 power shows the pair on the southwest edge of a large cloud of stardust. In a six inch reflector at 50 power a surprising number of additional double stars are clearly seen within the cluster's confines.

Webb describes NGC-752 as a "wide, rich region, especially of small stars". Strangely, Barns calls this cluster a "nebulous unit" in his 10 inch reflector, and adds "curious groupings". This stellar assembly is only about 1,200 light-years from us — relatively close as clusters go — accounting for its large apparent diameter in the sky.

Iota (ι) Trianguli

Forming a triangle with Gamma and Alpha Trianguli is the fifth magnitude star Iota, sometimes labeled six on star maps. This stunning combination of 5.4 magnitude gold and 7.0 magnitude blue suns is just four seconds of arc apart.

An acceptable view is found in a three or four inch telescope at about 70 power, but this pair becomes more striking with increased aperture. An eight inch reflector at 65 power, for example, gives a commanding view.

Colors given by classic observers include yellow and blue (Webb), and sapphire and gold (Barns). Smyth saw them as topaz yellow and green, and called this duo "exquisite".

Iota is seldom observed by astronomy enthusiasts — perhaps because it's overshadowed by its brighter and more famous neighbor, Gamma Andromedae. Both visible components have "invisible" spectroscopic companions orbiting about them, so at least four stars are involved in this neglected system nestled beneath the triangle.

M-33

"Very large, faint, ill defined; visible from its great size... in finder, a very curious object, only fit for low powers, being actually imperceptible, from want of contrast, with my 144 power." Such is Webb's description of the great spiral galaxy M-33 in Triangulum, as seen through his 3.7 inch refractor.

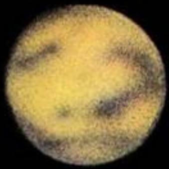
To find this elusive object, sweep with a low power eyepiece just above the midpoint of a line joining the stars Alpha Trianguli and Tau (τ) Piscium. Although quite bright (6.7 magnitude), M-33 is also very large — occupying an area much greater than the full moon (65 by 35 minutes). This results in low surface brightness, making the object easily overlooked.

Under good conditions, M-33 has been spotted in binoculars and large finders. A four inch reflector at 40 power shows a faint cloud on dark nights, even without using averted vision. Larger instruments reduce the contrast between galaxy and sky background but reveal bright notches of nebulosity within its extensive spiral arms. Viewing the arms themselves requires good seeing and transparency. Poor seeing blends them together, forming an amorphous glow in the telescope.

Perhaps the finest classic description of M-33 is by Barns: "Over 1/2 degree in extent, with crosses, rifts and nebulous condensations in a sea of glory!"

The famous Polish astronomer T. Banachiewicz said, "I am because I observe." In searching out the marvels of this region there may be a deeper meaning to existence. In seeking, glory is touched and greatness is found.

Planet Finder



Ⓐ Mercury

Nov.	1
R.A.	$13^{h}29^{m}$
Dec.	-7°07'
Mag.	-0.8

Ⓑ Mercury

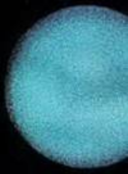
Nov.	15
R.A.	$14^{h}53^{m}$
Dec.	-15°46'
Mag.	-0.8

Ⓜ Mars

Nov.	1	15
R.A.	$6^{h}11^{m}$	$6^{h}08^{m}$
Dec.	+24°11'	+24°52'
Mag.	-0.8	-1.1

Ⓒ Ce

Nov.	1	15
R.A.	$4^{h}52^{m}$	$4^{h}4$
Dec.	+17°35'	+17
Mag.	+7.0	+7.



Ⓝ Nept

Nov.	15
R.A.	16^{h}
Dec.	-20°
Mag.	+7.

SUN

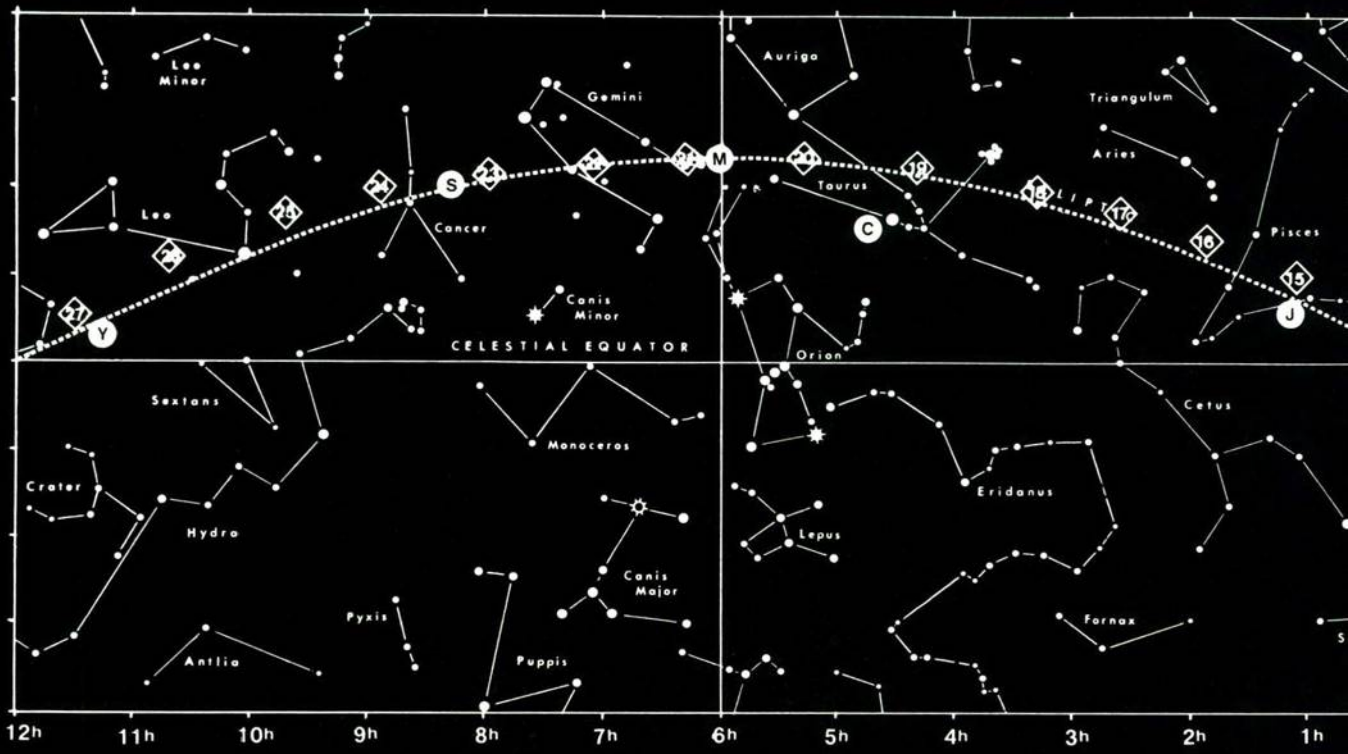
The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

Nov.	1	15
R.A.	$8^{h}20^{m}$	$8^{h}21^{m}$
Dec.	+19°39'	+19°39'
Mag.	+0.4	+0.3

Ⓤ Uranus

Nov.	15
R.A.	$14^{h}08^{m}$
Dec.	-12°26'
Mag.	+5.5

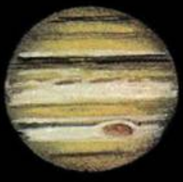

Leo Minor
Gemini
Auriga
Triangulum
Aries
Leo
Cancer
Taurus
L I P T
Pisces
Canis Minor
CELESTIAL EQUATOR
Orion
Sextans
Monoceros
Cetus
Crater
Hydra
Eridanus
Lepus
Canis Major
Pyxis
Fornax
Antlia
Puppis
27
26
25
24
23
22
21
20
19
18
17
16
15
Y
S
M
C
J
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag. = magnitude, a

November 1975

Vesta

ov.	1	15
.A.	23^h30^m	23^h31^m
ec.	-14°20'	-13°19'
lag.	+6.6	+6.6



Ⓙ Jupiter

Nov.	1	15
R.A.	1^h05^m	1^h00^m
Dec.	+5°17'	+4°47'
Mag.	-2.4	-2.4

Ⓨ Venus

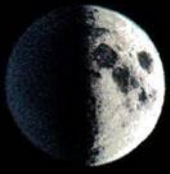
Nov.	1
R.A.	11^h32^m
Dec.	+3°11'
Mag.	-4.1

Ⓩ Venus

Nov.	15
R.A.	12^h26^m
Dec.	-1°21'
Mag.	-4.0

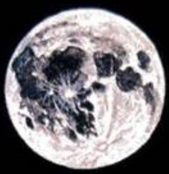
Ⓟ Pluto

ov.	15
.A.	13^h04^m
ec.	+11°04'
lag.	+14



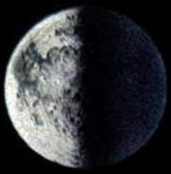
First Quarter

Nov. 10



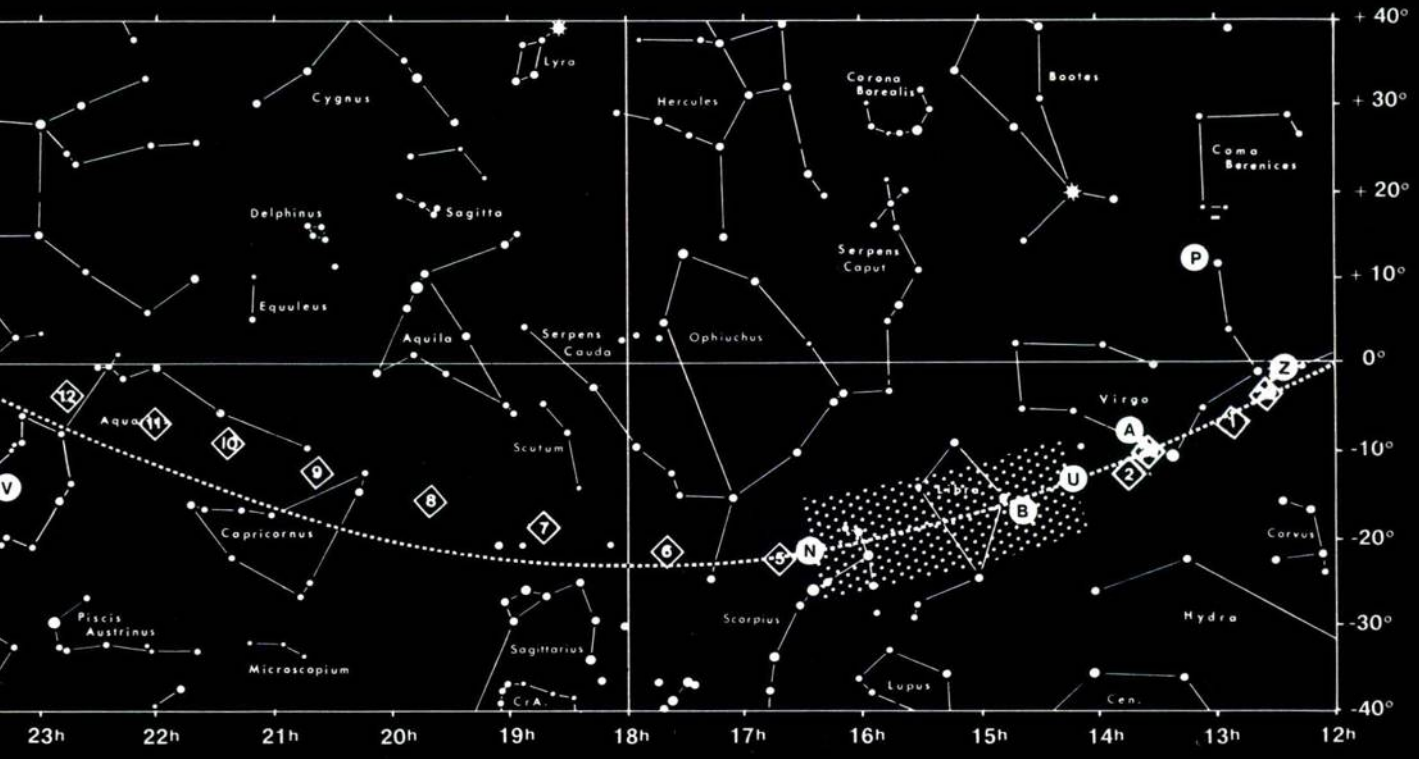
Full Moon

Nov. 18



Last Quarter

Nov. 26


+40°
+30°
+20°
+10°
0°
-10°
-20°
-30°
-40°
Lyra
Cygnus
Hercules
Corona Borealis
Bootes
Coma Berenices
Delphinus
Sagitta
Equuleus
Aquila
Serpens Cauda
Ophiuchus
Serpens Caput
P
Virgo
A
Z
Y
U
B
Libra
N
12
Aqua
11
10
9
8
7
6
5
2
V
Scutum
Capricornus
Corvus
Scorpius
Hydra
Piscis Austrinus
Microscopium
Sagittarius
CrA
Lupus
Cen.
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.

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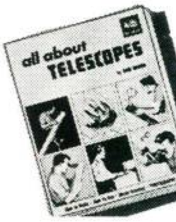

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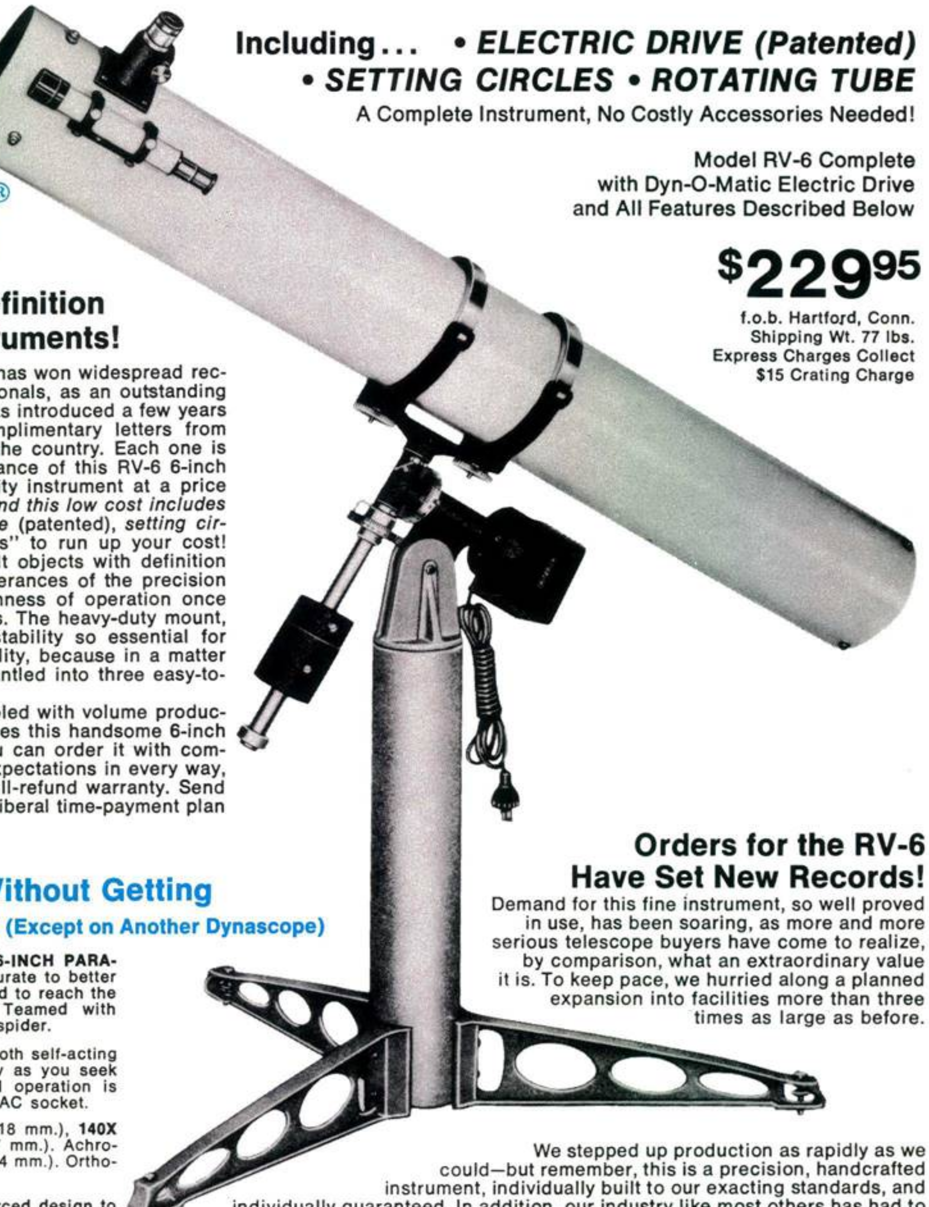

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II, 1 sec., 6 sec., 1 sec., 1 sec
Photo by Dr. James L. Matteson . . . Comet Kohoutek
Celestron 5½-inch Schmid
Camera, High-Speed Ekta
chrome, 3 minutes, Photo b
Dennis di Cicco . . . Th
Orion Nebula, Celestron 14-
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